INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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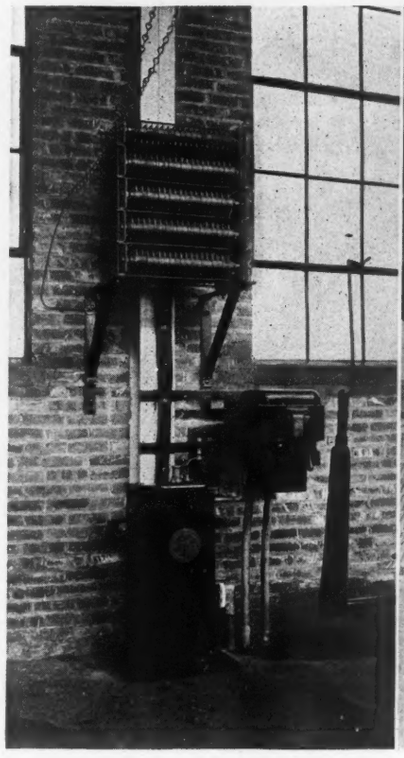
From the Standpoint of

Using Your Head as Well as Your Hands—

How Would You Rate These Jobs?



AMONG the letters that I have lately received commenting on what I have said in the June and July issues on the good and bad features of motor mountings, wiring and control arrangements is one from E. C. Nickel, one of our good friends in California. With that letter came these two photographs and the suggestion that they might appear under some such title as "Have you a job like this?" The illustration at the left shows the control installation for a 30-hp., 3-phase, slip-ring motor on the floor below. The one at the right shows runs of feeders in 3-in. conduit in the basement beneath the switchboard. The only comment about these pictures that Mr. Nickel made was that he is always interested in neat work, so that I infer these are offered as a challenge to others to show something better.

It is only fair to say, however, that I fear he has a trump card in reserve, for he did also say that he was unable to get photos of his best installations, owing to insufficient light to get a good daytime snapshot.

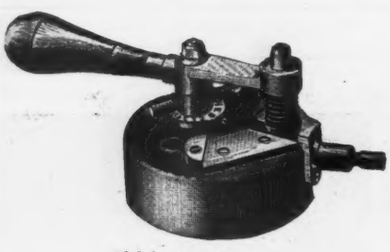
Personally, from the standpoint of a job that reflects use of the head as well as the hands in the installation, I would be forced to rate these jobs high. But there are two points about each that might be improved, one dealing with the installation details and the other with the layout. I would like very much to have those of you who are interested in high-grade work and have done a lot of it, to look over these pictures and write me what you think these two improvements might be, together with any suggestions other than installation and arrangement, such as type of equipment used, location with respect to each other, wiring details, general appearance of the job and the like. Don't try to "knock," but give good reasons for your suggestions.

Then we will ask Mr. Nickel to close the debate by telling whether or not he would accept the suggestions if he were to do the job again, and if not, why not.

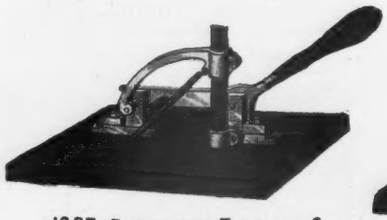
Practical Pete

Evolution of Disconnecting Switches

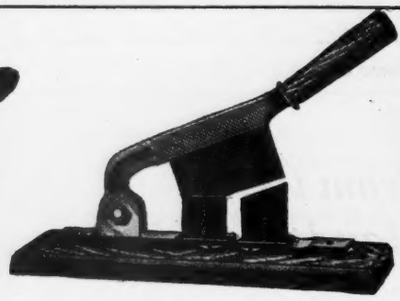
From 1884 to the Present



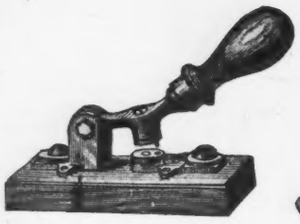
1884 - HEDGES



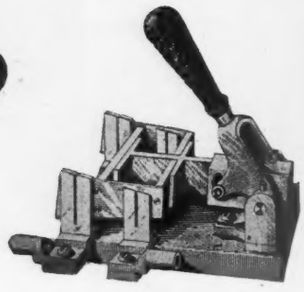
1887 - EXCELSIOR ELECTRIC CO.
Non-sparking



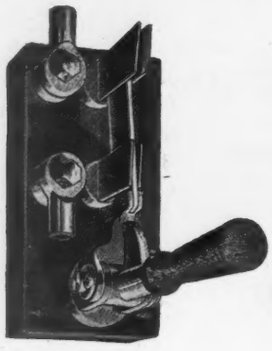
1888 - LANG



1889 - ELECTRICAL SUPPLY CO.

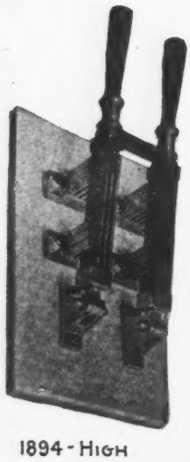


1891 - HUNT



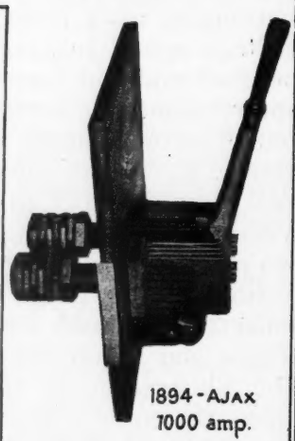
1892 - C and C

1893 - GENERAL ELECTRIC
Quick-break

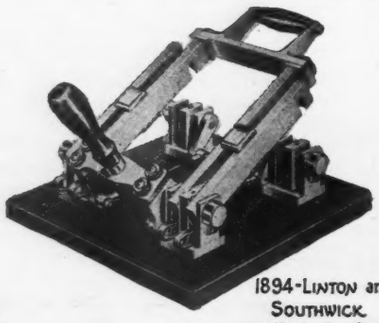


1894 - HIGH

THE first switches for electrical circuits were those used in telegraphy, but the development of electric lights and motors necessitated a heavier type of switch. One big problem was to make the switch open quickly, to prevent arcing. At first springs were used to open the switch blades suddenly. In 1893 the General Electric Company devised a switch in which the circuit was broken by light auxiliary blades which sprang open after the main blades were out. A pneumatic arrangement for blowing out an arc was part of one switch made in 1894. One feature of the older switches was that no current passed through the hinge. This practice was abandoned later and about 1902 switches very similar to the modern type began to be constructed. In 1912 manufacturers came to realize the importance of locking switches closed, to prevent opening under short circuit. One switch was arranged so that the jaws were tightened on the blades by means of a screw turned by an auxiliary handle. Another switch had the clips so formed that they must be opened wide before the switch blade could be withdrawn. The locking latch of the Condit Electrical Manufacturing Company, devised in 1912, was the forerunner of other devices which are now being widely used for this purpose.

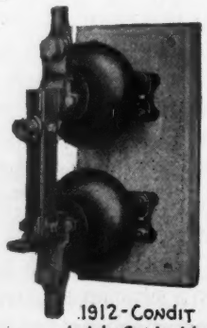


1894 - AJAX
1000 amp.



1894 - LINTON and
SOUTHWICK
Bolted Contact

1894 - OHIO BRASS
Pneumatic quick-break



1912 - CONDIT
Latch for locking

IN THIS ARTICLE definite examples show things accomplished in revamping power service to meet new operating conditions in a large shop. The results secured plainly indicate that there are few real excuses for continuing out-of-date methods.

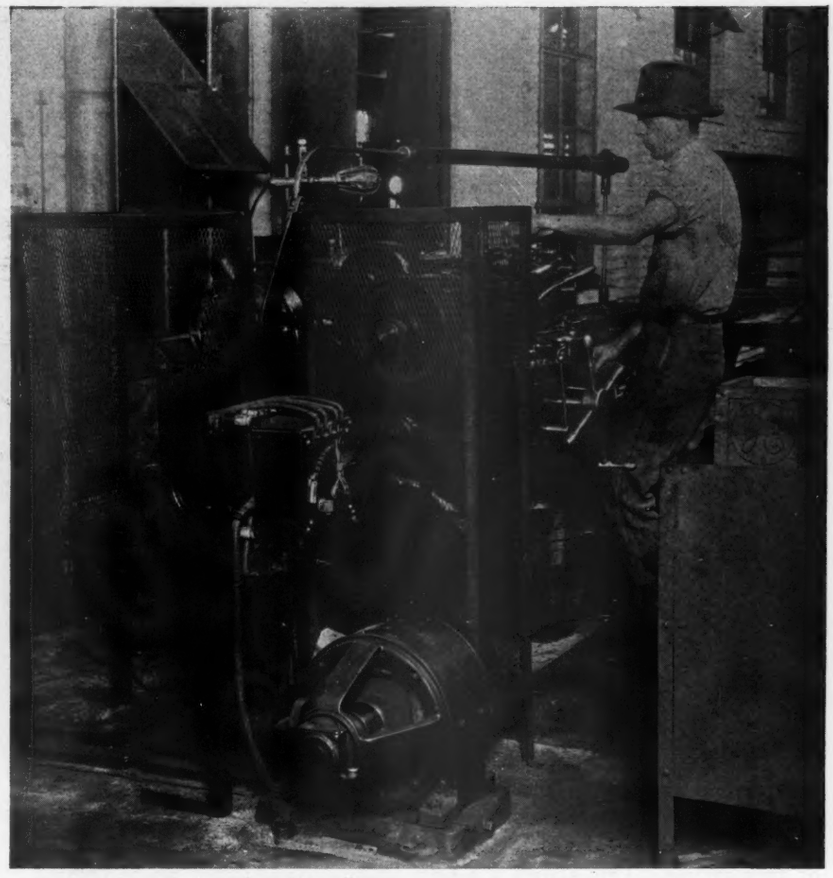
This Shop Changed its

Power Service on Machine Tools

And Many Operating Advantages Have Resulted

By ROBERT HARRIS,

Chief Electrician, William R. Thropp and Sons Company, Trenton, N. J.



Ease of manipulation, accessibility of the motor and its control and ample protection to the operator are skilfully combined in this example of the application of power service to a lathe

DRIVING machinery from a line shaft, as compared to individual motor drive, may be likened to running a whole machine shop in order to use a drill press. One glance at a shop which is cluttered with belts and line- and counter-shafts gives convincing evidence of the friction losses, the first cost and the maintenance expense of belts and bearings and the loss of power occasioned when only one machine in a group has to be used. The elimination of this condition is important from the standpoint of reduced operating and maintenance charges, with greater flexibility and control of service.

From the standpoint of safety individual control is supreme. Control equipment may be so arranged that the mere pressure of a finger will stop the heaviest machinery and prevent injury to the operator, the apparatus or the product being worked upon. Overload devices may be adjusted to prevent any overtaxing of electrical or mechanical apparatus. Interruptions with individual drive tie up comparatively little production. Only one machine will be stopped and the substitution of a comparatively small motor or control part will get it back into operation.

THE GROWING adoption of individual motor drive is due to a clear recognition that it offers, among other advantages: (1) Economy in machine operation, flexibility and ease of control; (2) Elimination of waste of power through the friction of belts and line- and counter-shafts; (3) Decreased risk of injury to operators, equipment and products; (4) Less production tied up by failure of one or two motors; (5) Better distribution of light, from elimination of belts and overhead equipment; (6) Improved appearance of the shop. In this article Mr. Harris describes some of the interesting features of the control and motor-mounting methods adopted at the plant of William R. Thropp and Sons Company.

Last, but of no little importance, is the good appearance which is possible with individual motor drive. It is easy to demonstrate that taking down belts and shafts will allow a better distribution of light, and thus increase the efficiency of machine operators.

In the accompanying illustrations some examples of individual motor drives are shown that have replaced overhead belt drives in the plant of the William R. Thropp & Sons Company, Trenton, N. J. In these shops a large number of machine tools have been changed over. Direct drive has been used where possible and in other places gears, chains and short belts have been employed. The control stations have been placed convenient to the operator. The motors have been mounted either on the machines or on the floor in out-of-the-way locations. All wiring has been enclosed in rigid conduit which was run around the edges of the machines so as to be out of the way and inconspicuous. The service is at 220 volts direct current generated in the plant of the company, so that variable-speed direct-current motors

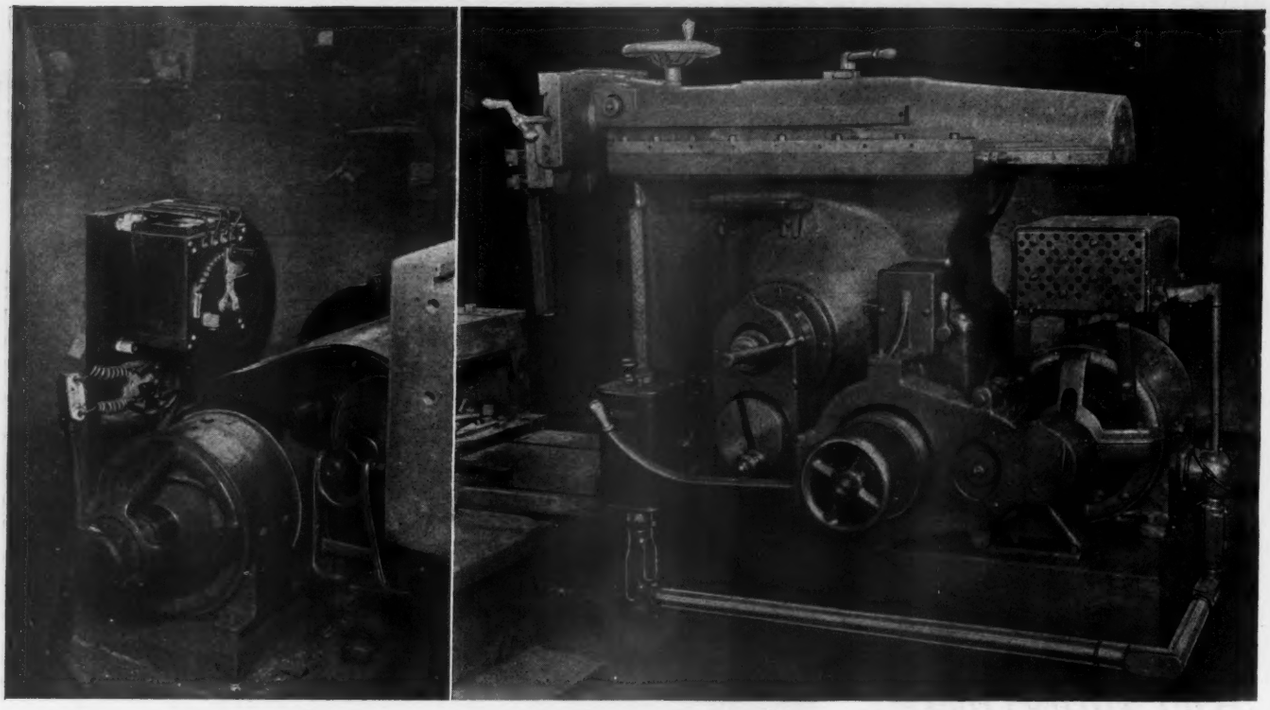


Fig. 1—Here are two good examples of individual drive and control for machine tools.
At the left is a simple, direct-current starting box for a 5-hp. motor driving a key seater. At the right is a variable-speed, 10-hp. motor which drives a Cincinnati shaper.

may be used to advantage where necessary.

A typical example of the simplest form of drive and control is shown in the illustration at the beginning of this article. This shows a 5-hp., 1,150-r.p.m. motor mounted on an ordinary slide-rail bed plate and connected to a lathe by a short belt, which is kept tight by an idler pulley. The ordinary direct-current starting box is mounted on a slate base with a double-pole knife switch and is supported by 1¼-in. angle irons bent at the floor and bolted to it. The conduit is brought down against the back wall and from the wall runs in a straight line out to the motor.

This illustration also shows clearly the guard screens which are placed around the revolving pulleys at the end of the machine. Screens of this type are used around belts, pulleys, and other moving parts throughout the factory. They are made so that they can be lifted out of place when it is necessary to make repairs upon the machinery and the corners are hinged to make them more convenient in handling. They are heavy enough to stand in place and to prevent injury to persons who might come too near the revolving parts.

Another example of how a direct-current starting box may be mounted is shown at the left in Fig. 1. This starting box is held by 1½-in. steel straps, which are bolted to the cast-iron base and to the side of the motor. The motor is a 5-hp. 1,150-r.p.m. machine and drives a Mitts & Merrill key seater. A special base was cast for it, with a projection on the end to accommodate the motor.

Examples of variable-speed motors and control are shown at the right in Fig. 1 and in Figs. 3, 4 and 6. The control arrangement in all these cases follows the scheme shown in Fig. 2. In Fig. 1 (at right) is shown a Cincinnati 32-inch bell-crank shaper which is driven by a 10-hp. motor with a speed of 400 to 1,600 r.p.m. When this motor was applied to the machine a new cast-iron bed plate was made, extending under the motor, the machine and the table which is at the left of the machine. At the time this was done it had been decided to make a new and longer bed plate for the table and therefore it was worth while to extend the end of the bed plate at

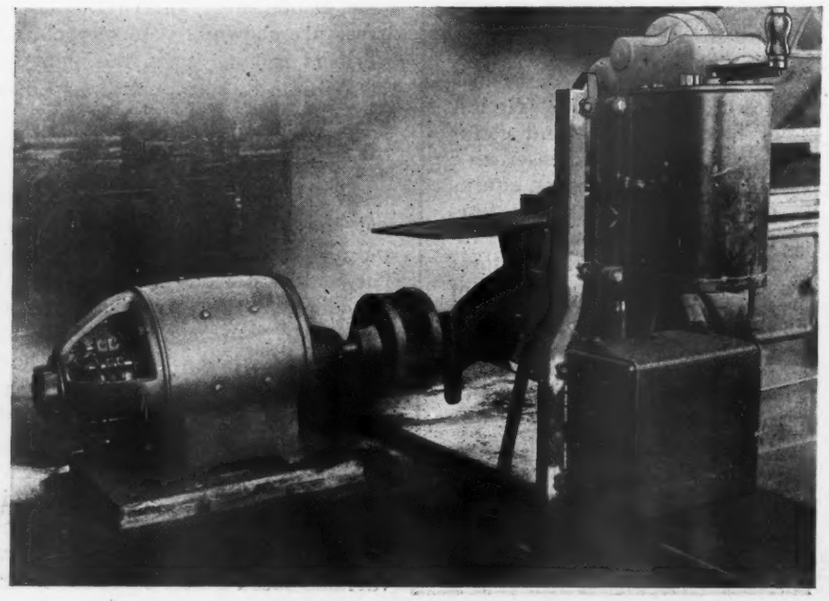


Fig. 2—A variable-speed motor which drives a grinder.
This is a 15-hp. motor running at 400 to 1,400 r.p.m. and driving a grinder through a flexible coupling. The controller and its resistance box are mounted on an angle-iron and strap-iron frame at the left of the machine.

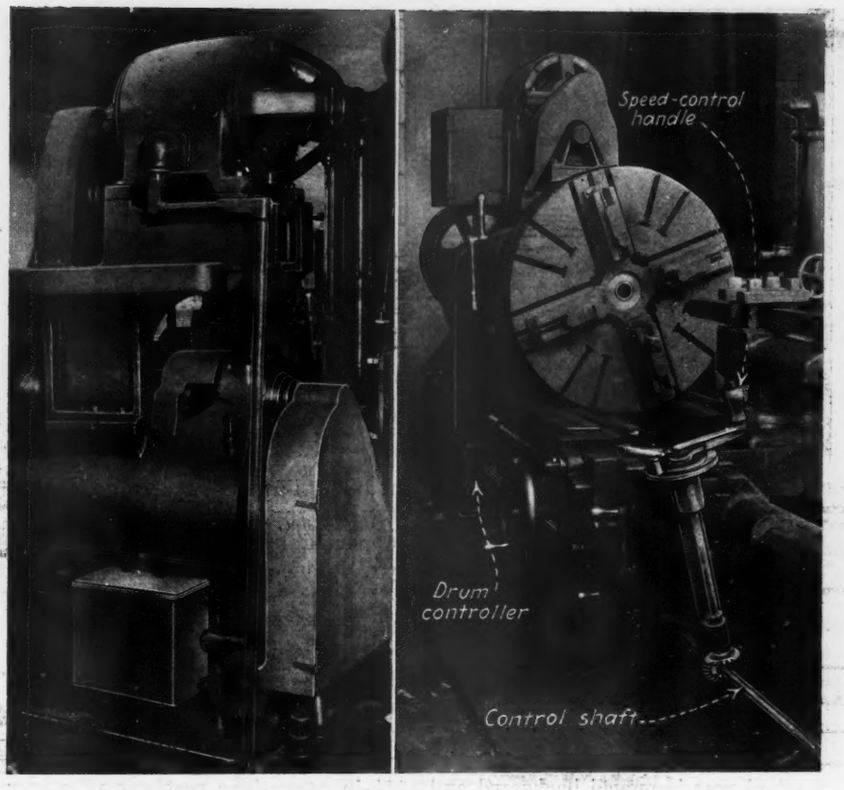


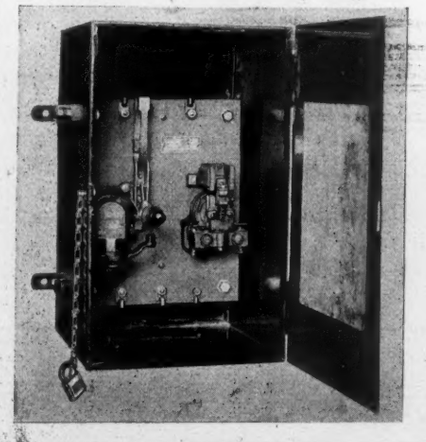
Fig. 3—Variable-speed drive for 42-inch lathe.
This shows the back and the front of the machine. The speed of the lathe is controlled by the handle which travels with the carriage, as shown in the picture at the right.

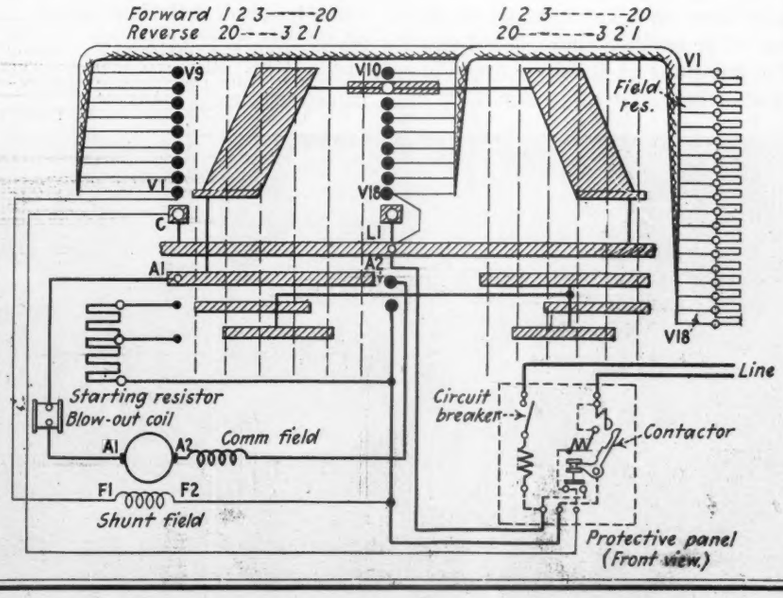
the opposite end of the machine to accommodate the motor. As may be seen, the motor is gear-connected. The controller is of the drum type and is located near the base of the machine toward the working end. Connection is made through conduit which runs around close to the bed plate at the floor, making a very neat job. An enclosed motor-terminal box is used on this installation and on most of the others in the plant. The most convenient place for mounting the control resistance was on ½-in. by 1½-in. strap iron above the motor. The heat from the control resistance rises and does not increase the temperature of the motor. It will be noted that there is not an inch of exposed wire on this entire job.

The controller used on this machine and the others driven by variable-speed motors is of the drum type (General Electric Company CR 3105). The line comes into the motor through a protective panel which is not shown in the illustration. This panel has a one-pole overload relay on one side of the line and a low-voltage protective relay in the other side. As may be seen from the diagram in Fig. 4, if voltage goes off the line or the overload relay trips, the low-voltage coil will release itself and open one side of the line. When the voltage comes back on the line, or when the overload relay in one side of the line is closed the circuit will not be completed until the handle of the controller is brought back to the starting or zero position.

An adaptation of a variable-speed motor to a Driggs 42-inch lathe is shown in Fig. 3. At the left-hand side of this picture is shown the back of the lathe. This gives a good view of the motor mounting. A special cast-iron bracket was made to hold the motor and the two intermediate gears through which it drives. The motor is rated at 10 hp. and has a speed of 400 to 1,200 r.p.m. The control arrangement is the interesting feature of this installation. As seen from the front

Fig. 4—Control and protection for machine-tool driving motors.
Drum controllers and protective panels are used on many of the individual-drive motors in the Thropp plant. The diagram shows the connections, while the other illustration shows the protective panel box which is mounted on the wall. This panel prevents the motor starting when voltage is restored to the line after a voltage failure. The contactor opens the circuit on low voltage and will be reset only when the controller handle is brought to the off position. A single-pole, instantaneous-trip circuit breaker provides overload protection. The tripping of this breaker opens the contactor so that on overload also the control handle must be brought to the off position before the motor circuit is closed.





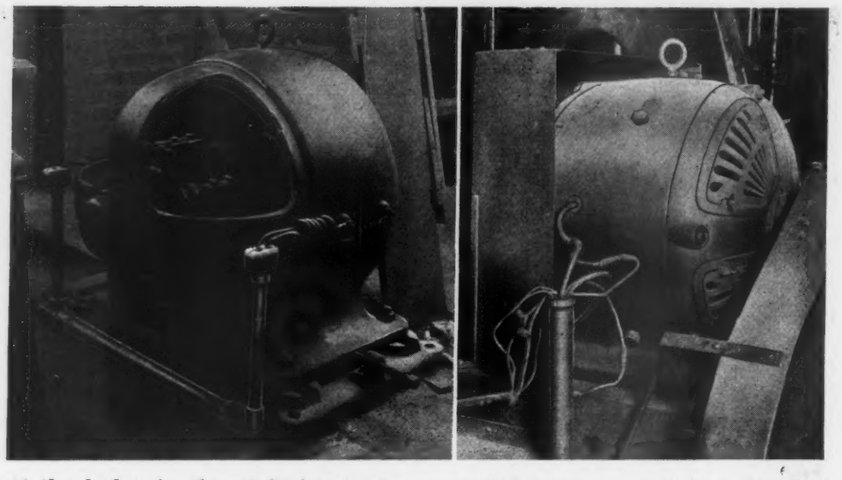


Fig. 5—A good and a bad example of wiring old-type motors.

At the left is shown the way in which a good job was made under hard conditions. The old types of motors have exposed terminals on both sides of the frame. A neat job was made with the two upright pieces of conduit and the coil wires leading to the terminals. Straight runs of wire could not be made to the terminals because the motor has to be shifted in order to tighten the belt. At the right is a good example of how not to do it. This was a war job, which has since been changed and the motor properly installed.

of the lathe, in the right-hand picture, the control handle is mounted so that it travels with the carriage. This control handle is connected by means of bevel gears to a strong shaft at the front of the lathe and this shaft in turn operates the drum controller, which is shown at the left of the photograph near the floor. The gear on the long shaft is keyed to it and, of course, slides along as the tool rest is moved backward and forward. The control of this machine is the same as that of the key seater which was described in a preceding paragraph.

A 24-inch Gisholt turret lathe is shown in Fig. 6. This lathe is driven by two motors shown at the left of the illustration, and the control is mounted at the left end and in front of the lathe. The main motor is rated at 10 hp. with a speed of 400 to 1,600 r.p.m. It drives the lathe through a flexible chain and is mounted upon a cast-iron plate which in turn is bolted to the lathe. It is further supported by a 2-in. pipe which rests on a large flange on the floor. The smaller motor is rated at 2 hp. and runs at 1,150 r.p.m. This motor drives the oil pump. It is mounted upon a cast-iron bracket bolted to the lathe and in addition is supported by a 1¼-in. pipe rising from a large flange on the floor.

The control for both of these motors is located in front of the lathe as shown in the photograph at the right. The starting box for the small motor, the drum controller and the control resistance are all mounted upon a frame made up of ½-in. by 1½-in. strap-iron resting on the floor and bolted to the side of the machine.

The control of the variable-speed motor is the same as in the two cases mentioned before.

A Neat Job on Old-Style Motor Terminals

A contrast between what is often done and what can be done in making a job which looks neat and is safe is shown in Fig. 5. This shows two motors of old types, on which it was hard to make connections that look well. At the left is an example of how a bad condition like this may be taken care of in a clean-cut manner. The motor terminals are on both sides of the frame and the wire originally ran along the floor and up to the terminals. A little effort of brain and hand, however, resulted in the very neat arrangement which is shown. Wires have to be taken off at two points and this is accomplished by putting in two riser pipes headed by porcelain outlet boxes. Straight connections to the terminals cannot be made from the outlets on account of the fact that the motor has to be shifted from time to time to keep the belt tight. The belt is fairly long and the pulley is small; therefore the position of the motor must occasionally be changed to tighten the belt. The way out of the difficulty was to make the neat coils which are shown.

Only by way of contrast is the picture at the right-hand side of Fig. 5 shown. Aside from the very poor appearance, this construction is dangerous, inasmuch as the wires are liable to be cut by the edges of the pipe or by the sheet-iron box around the end of the motor. This motor was put in hurriedly, during war times, when many things were overlooked in order to get machines to work quickly. This job was, however, changed and the motor properly installed long ago.

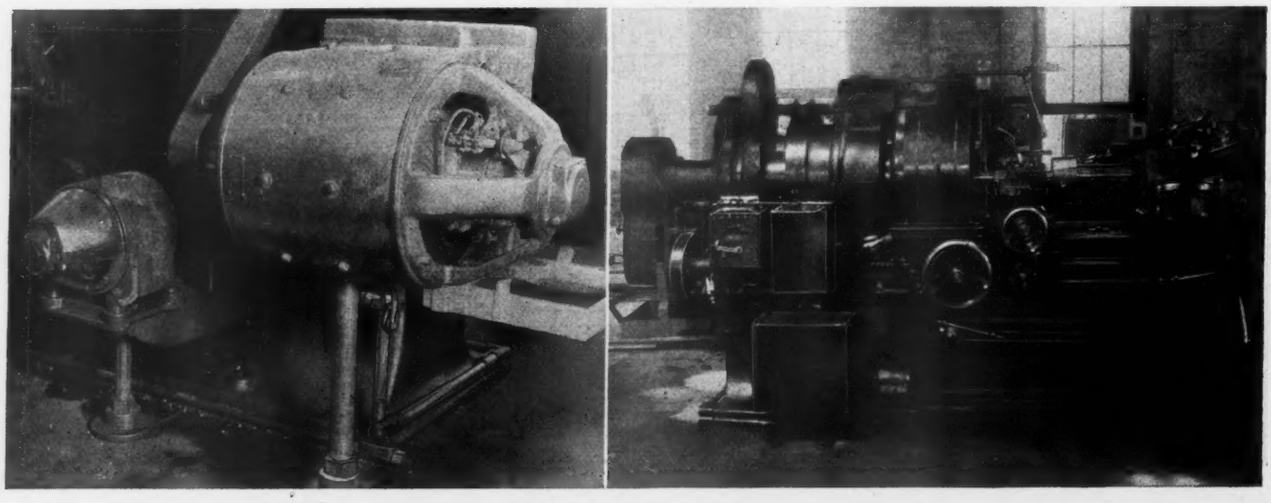
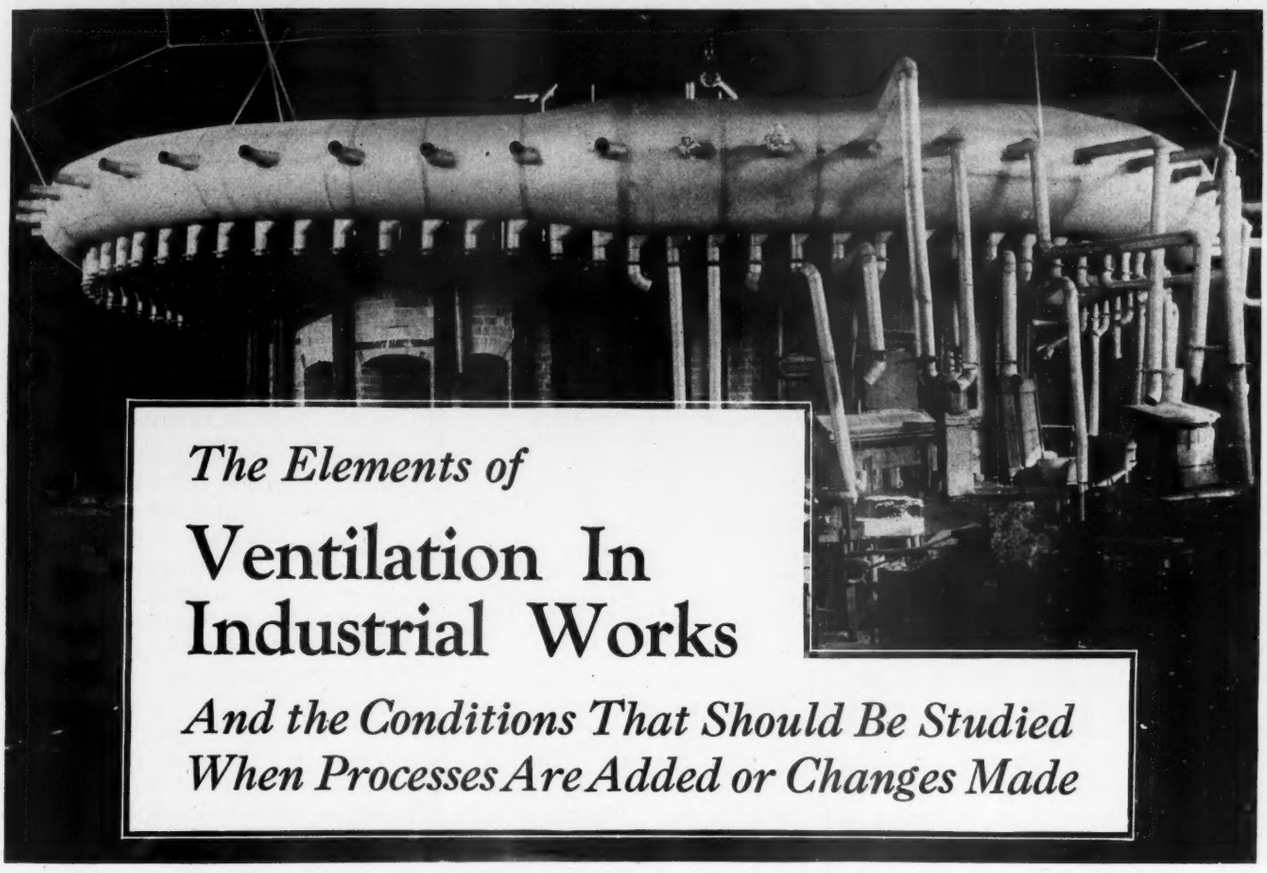


Fig. 6—A turret lathe driven by a variable-speed, individual motor.

At the left is shown the rear of the machine with a main 10-hp. motor and a 2-hp. oil-pump motor. The control is from the front of the machine as shown at the right.



The Elements of

Ventilation In Industrial Works

And the Conditions That Should Be Studied When Processes Are Added or Changes Made

Galvanized ducts from the numerous drop outlets, each of which is controlled by a damper, carry the air down to cool the hot glass or the workmen at the Royersford, Pa., plant of the Diamond Glass Co. The ducts at the left are disconnected.

By FRANK E. GOODING
Associate Editor, Industrial Engineer

VENTILATION involves the stirring up and removal of impure air in an enclosed place and its replacement with pure air. In offices, homes and buildings in which crowds gather, as churches and theaters, the larger share of the impurities come from the breath and contact of the air with the human body. Industry, however, has in addition to these, certain other conditions arising from industrial processes, such as dust, fumes, vapors and other impurities, which are often more detrimental to comfort and health than the exhalations and have a more serious influence in tending to prevent maximum production. The correcting of these conditions presents many difficult problems. Most ventilation problems, however, are based on removal of the breathed air or its dilution with fresh air.

Pure air contains about 20 per cent oxygen, 78 per cent nitrogen and 0.04 per cent CO_2, or carbon dioxide. After breathing, the oxygen content is reduced to about 16 per cent and the CO_2 is increased to 4 per cent. Because of the accuracy with which the amount of CO_2 in a volume of air can be measured, it is generally taken as the indicator of its purity and is usually expressed by the number of parts of CO_2 in 10,000 parts or volumes of air. Thus, pure air contains four parts per 10,000; to this quantity already in the air in any enclosed space must be added the CO_2 exhaled, which, according to various authorities, amounts to 0.6 cu. ft. per hour per person. Combustion also gives off CO_2 which helps to devitalize air.

IF THE AIR were contaminated by breathing only, industrial ventilation would not be a serious problem, because few factories are crowded. Many industrial processes, however, create heat, fumes, vapors, dust or odors which are not only dangerous but difficult to handle. The principles underlying good ventilation and some of the methods of applying these principles to special cases are described and illustrated in this article.

An ordinary gas jet produces 2½ to 5 cu. ft. of CO_2 per hour. It has been found that if the CO_2 content gets above 12 parts per 10,000 discomfort may result, and so proper ventilation requires the removal of enough of the impure air and its replacement with sufficient fresh air to keep the proportion of CO_2 down to 8 to 10 parts per 10,000 volumes of air. To get this standard requires approximately 1,000 cu. ft. of air per hour per person for 10 parts of CO_2; 1,200 cu. ft. for 9 parts; 1,500 cu. ft. for 8 parts; 2,000 cu. ft. for 7 parts; and 3,000 for 6 parts of CO_2 per 10,000 parts of air. In very large rooms or spaces where each occupant has 1,000 cu. ft. or more of air space a somewhat less volume of air per hour will maintain the air at the required standard of purity.

It is not only the CO_2 in the air which causes trouble and makes it unfit to be breathed, but the CO_2 content is an easily measured unit which exists with and in approximately the same proportion as the other and less easily measured contaminating elements. For this reason the CO_2 content per 10,000 vol-

umes of air is generally used as the index of its purity and is the basis of legal standards in many states and countries.

Some authorities in ventilation problems have found that it is possible to live in air with 5 per cent of CO_2 if it is kept in circulation, although under actual conditions it seldom gets as high as ½ of 1 per cent, or 50 parts of CO_2 in 10,000. Frequently, before state or city authorities took over supervision of industrial ventilation, tests showed 20 to 30 volumes and sometimes over 50 volumes of CO_2 per 10,000 volumes of air in extremely foul and ill-smelling rooms with open gas fixtures.

The decrease in the oxygen content is hardly noticed and under ordinary conditions never gets low enough to affect the occupants. Experiments have shown that the oxygen content of a room must be reduced from 20 per cent to approximately 15 per cent before any ill effects are noticed. As a person uses only 20 cu. in. of air at each breath, the effect upon the oxygen would be so slight as to have no appreciable effect upon the ventilation problem.

In addition to diluting the CO_2 in the air, industrial plants may require ventilation due to one or more of several other conditions, most of which result from the processes being conducted.

In practically all ventilation problems the air surrounding the workers must be removed and supplanted with fresh air, as that is generally more economical than trying to filter or wash the objectionable elements out and use the air again. In some cases, however, where the air is heated in the process, it may be treated and again used for heating and ventilating purposes.

Providing enough air to remove these objectionable conditions will in practically all cases dilute it sufficiently to reduce the CO_2 content to the 8 or 10 parts per 10,000 permissible. Thus, in industrial work another indicator, the number of changes of air per hour, is more often used to indicate the ventilation requirement than the CO_2 content. This varies with the type of building, the line of work and the industry, however, and is difficult to determine exactly. Six changes an hour will take care of ordinary requirements.

Still another method is to base the ventilation requirements on the cubic air space per individual, as is used by the Illinois ventilation law for factories, mercantile establishments, mills and workshops. This requires 500 cu. ft. of air space per person employed. However, if no lights are used which consume oxygen, 250 cu. ft. of air space is sufficient. If the building has 2,000 cu. ft. of air space per person and has outside windows and doors with an area equal to ⅛ the floor space, no artificial ventilation is required, provided that the rooms are aired before beginning work and at meal hours. Also under this law plants having between 500 and 2,000 cu. ft. of air space per person must supply 1,500 cu. ft. of air per person per hour. In addition, the law requires that poisonous or noxious gases or fumes and all dusts arising from or created in the process shall be removed as far as practicable by ventilating or exhaust devices. Where these conditions are met the changes of air resulting are generally much greater than necessary to maintain a low CO_2 standard.

Industrial Conditions Which Necessitate Artificial Ventilation

(a) *High Temperature.*—This may result from summer heat or from heat used or generated in the process, as around furnaces or ovens.

(b) *Humidity.*—Many textile processes, paper mills and some other industries free a large amount of moisture as a part of the process. A hot, moist atmosphere is very disagreeable. Other processes, such as wet grinding, give a cold, wet atmosphere.

(c) *Prevent Bacterial Growth.*—Warehouses, particularly where grains or food products are stored, often require ventilation to prevent bacterial growth. Leather and leather products must be protected from mildew, for example.

(d) *Dust.*—Some processes require extremely dry atmospheres, as in tobacco factories and cement mills. In these the dust conditions must be met primarily by ventilation. Dust must also be removed in many other industrial processes, as dry grinding, buffing, sand blasting and others.

(e) *Fumes or Vapors.*—These are particularly objectionable in many chemical processes and received much study during the war, especially in the manufacture of explosives.

(f) *Odors.*—These are closely related to fumes and are disagreeable in some industries, as in fertilizer works, tanneries and some others. Every industrial plant, however, is confronted with the problem of ventilating toilet, locker and wash rooms.

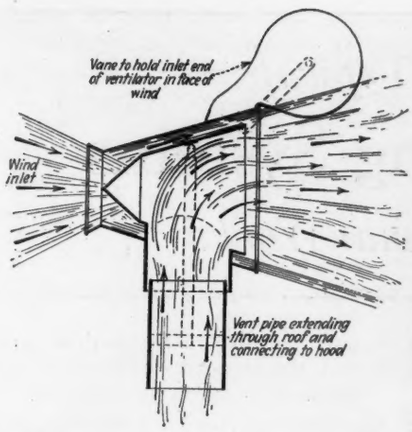
(h) *Stagnant Air.*—Without ventilation, either natural or artificial, air tends to settle around or "coat" workers, especially those who do not move around at their work. These stagnant air pockets or "hot spots" around a machine or furnace are usually helped by merely stirring up the air. Some means must, however, be provided for getting this air out of the room and replacing it with fresh air.

Methods of Ventilating

The most common type of ventilation is by gravity or natural draft. Open windows and doors let in a large amount of air and in plants with large air space per person and with but little contamination from the processes this may be sufficient. There is difficulty, however, in controlling the ventilation and equalizing it in all parts of the shop, as natural ventilation is largely dependent upon the direction and velocity of the wind. Windows, while of great importance in ventilation, are primarily to let in light and only in special cases can be depended upon to provide all necessary ventilation. They perform a very essential auxiliary ventilating service, however, and require consideration in the solution of the ventilation problem. Even in the most ideal situations care must be exercised in the operation of the windows. For exemple, if the windows on both sides of a monitor roof are open the air blows straight through, or "short circuits" the floor and does not pass through the building and force out the impure air, although some is siphoned out. In such a case the windows on the side of the monitor opposite to the wind should be opened and also windows toward the wind on the floor so that the air enters the room near the floor and goes up and out through the monitor.

What Roof Ventilation Will Do

With saw-tooth roofs, natural ventilation is difficult when the wind is blowing directly into the open windows. One method of providing ventilation independent of the direction of the wind is by the use of cowls or other aspirating devices, of which there are a number of types available. The simplest is merely a chimney or vent pipe, with or without a shield to prevent rain entering. Due to the difference in the tempera-



Cross-section of one type of roof ventilator.

The principle upon which all ventilators operate is that as the wind blows past the ventilator its velocity exercises a suction which draws other air with it. In this ventilator, which is practically a double-walled cone, the velocity of the wind through the space between the two walls exerts a suction on the inner cone. A weather vane keeps it pointed toward the wind. At the right is a photograph of this type.

Two of several types of roof ventilators which siphon the air from a room by the action of the wind.

The Globe ventilators at the left remove heated air from a power plant. The Sturtevant ventilators above are installed on a shoe factory. Notice the method of serving the lower floors. The action of this ventilator is explained in the sketch.

ture of the air inside and outside the room, gravity will cause some ventilation, which will increase or "draw" stronger as the velocity of the wind increases. By various designs, two of which are shown on this page, the "drawing" or siphoning action of this roof ventilator is increased. The capacity of various sizes of the Sturtevant Autoforce ventilator, which is shown in the sketch, at a wind velocity of 8 miles per hour is given in Table 1.

These are often used as outlets, in connection with ventilating systems which force air into the room. This is especially true around dye houses, textile and paper mills, where warm, dry air is forced in to absorb the steam arising from the process. Otherwise the moisture would condense on the ceiling and rust out the steel work. Also, it discomforts the workers and often damages the product when the condensate collects in large drops and falls, bringing with it rust or dirt from the ceiling. This is due to the fact that the warm, moist air striking the comparatively cold ceiling becomes cooled by contact and therefore deposits some of its moisture. This condition is so bad in some cases that special means for warming the ceiling and overhead structures are necessary.

Using Hoods to Remove Vapors, Heat or Fumes

These ventilators are often used with hoods to remove gases, steam, or heat as are given off by cyanide case-hardening furnaces, plating vats, cooking and other processes. Because these hoods must be designed so that they will not be in the way of the workers and still collect obnoxious gases before they become diffused in the room they are generally placed some distance above the furnace or vat. The general practice in such is to extend the hood at least six inches over each edge of the vat for each two feet it is necessary to place the hood above the level of the top of the vat. For example, on a vat 3 ft. by 5 ft., a hood placed 18 in. above would be 4 ft. by 6 ft.; a hood placed 3 ft. above would be 5 ft. by 7 ft.

Ordinarily the outlet pipe of the hood is made 1/16 of the area of the hood mouth. For example, with a hood 4 ft. by 6 ft. the area of the outlet pipe would be 1/16 of 24 sq. ft., or 1.5 sq. ft. A pipe 17 in. in diameter would be large enough if it were not too long or had bends which would increase the friction loss. The velocity at the mouth of the hood would be 100 to 200 ft. per min. under ordinary conditions.

Many times these hoods are made adjustable in height so that they can be lowered to collect all fumes during the process but raised out of the way when the operators need to get at the vat or furnace. Sometimes a double hood is constructed with about an inch of space between the inside and outside hood at the mouth. The inner hood tapers in more rapidly than the outside hood. This gives a high velocity of inrushing air around the outer edge of the hood and is more likely to prevent any fumes or vapors from getting away from the ventilators and out into the room.

Natural draft with a roof ventilator and inside hood is most satisfactory, however, when the fumes or vapors are light. When heavier than

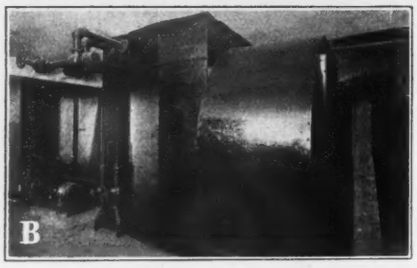
Capacity of Roof Ventilators

Dia. Inches	Cu. Ft. per Min.	Dia. Inches	Cu. Ft. per Min.
4	5,000	16	75,900
6	11,300	18	90,800
8	20,100	20	101,700
10	31,400	24	156,000
12	45,200	30	300,000
14	61,500	36	400,000

Table I—The pulling power of natural draft ventilators.

This table shows what different sizes of one type of roof ventilator can do at an average velocity of 8 m.p.h. This capacity increases or decreases with a corresponding change in the velocity of the wind.

A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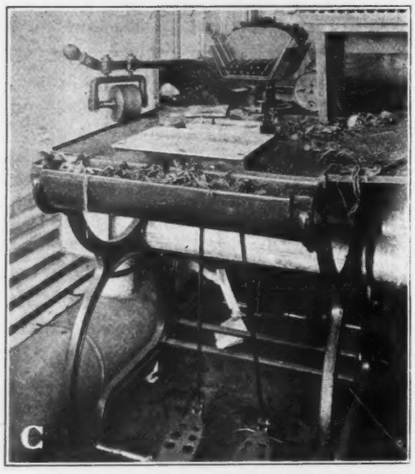
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Some Typical

Ventilating Systems

in Industrial Works

A—Fumes from these vats are drawn off through propeller fans spaced along the wall.

B—Air conditioning outfit for washing and purifying the air before it is distributed.

C—Special suction pipes leading to this cigar wrapping table hold the leaves in place while being rolled and draw away all tobacco dust. Factories frequently put an exhaust in the work bench.

D—Here the outlets are placed along the wall between the windows and curved to direct the air outward and down to carry away the heat from open gas flames.

E—A plenum and exhaust system are in combination in this rubber glove factory. The exhaust system draws the air away from the vats with a peculiar type of suction hood. Conditioned air of low humidity to aid in drying is distributed by ceiling ducts.

F—This equipment for cleaning furs includes practically all the details of any industrial exhaust system, except that it discharges in the open air instead of into a dust collector. Notice particularly the shape of the hood, the taper of the main suction pipe, and the dampers just above the hoods to shut off any section.

G—Chain drives or belts are used on large fans such as this, which are usually of too low speed to be direct connected.

H—This motor is direct connected through a flexible coupling, as it runs at high speed and delivers air at a higher pressure.

I—Drawing air over stocking forms in the finishing department of hosiery mill by propeller fans.

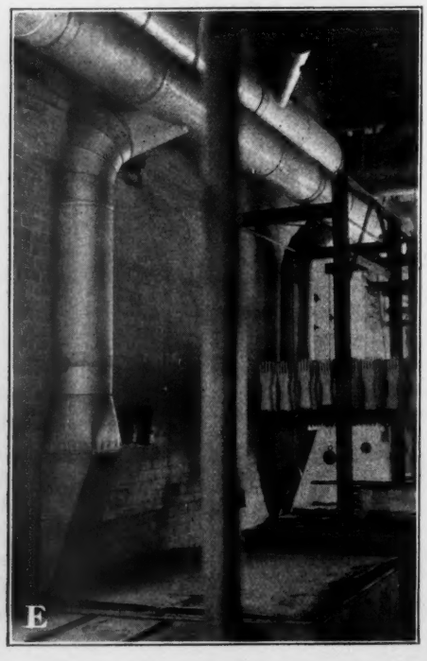
J—This belt-driven double blower is placed in the center of the shop to divide the duct in two.

K—Large amounts of steam given off in dye houses cause high humidity and oppressive working conditions. Duct outlets extend down to the dye vats and also up from the main duct to collect any steam which escapes to the ceiling.

L—This picture was taken of the view as in "K" with the ventilating system shut down.

M—These special hoods and vent pipes exhaust the steam from hat-forming machines. The large duct at the ceiling is part of the heating and ventilating system.

D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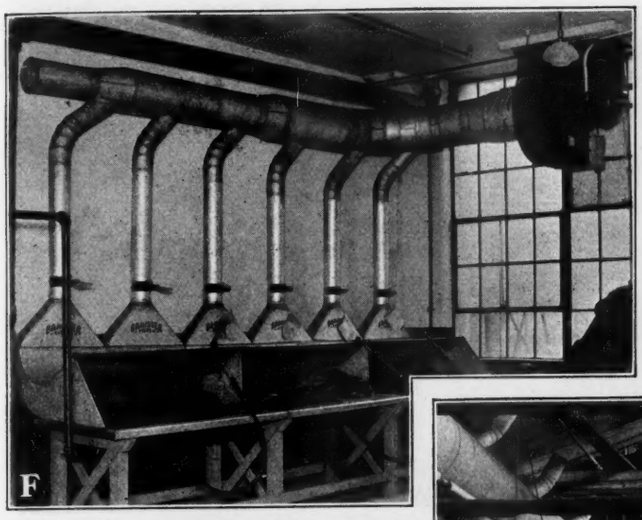
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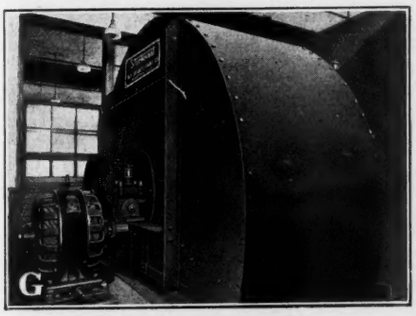
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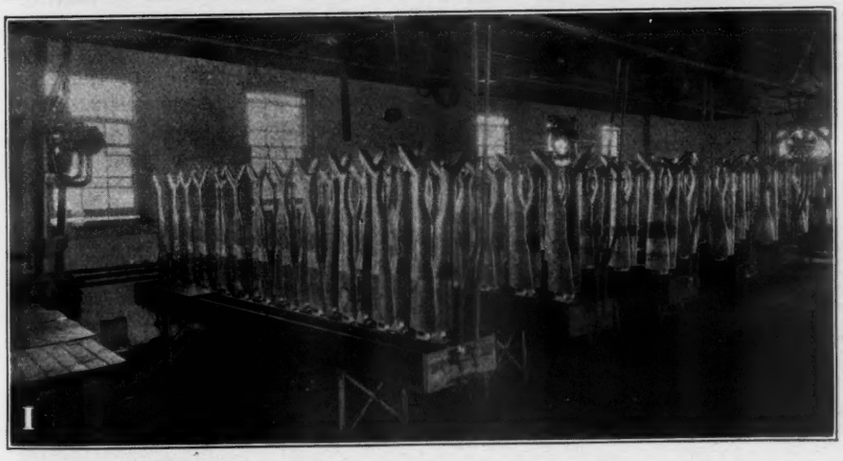

I

M

Propeller fan exhausting steam through a pent house.

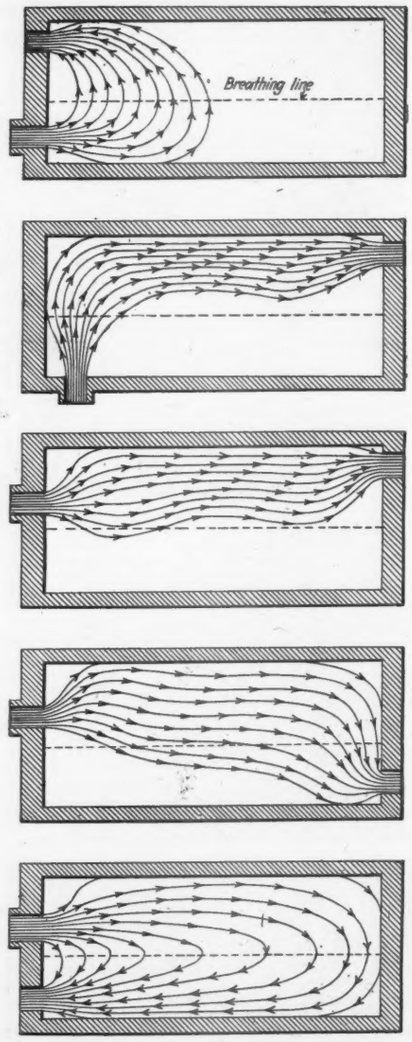
In this case the propeller fan is placed in the pent house and is connected by a duct to the floor below, as is shown in the sketch at the right. The outlet is protected by louvres, like shutters, which close the opening where the fan is not running and so prevent a back draft, or rain or snow from entering. Care should be exercised in placing these so that the opening is opposite to the prevailing winds.

air or when natural draft is not sufficient, fans or blowers are often used in connection with these hoods or suction pipes. Two methods of locating these fans are shown in the sketch on the opposite page.

Preventing Stagnation and "Hot Spots"

Sometimes, particularly in a large room, or even in a small one where the air currents "short circuit" past corners or miss other areas, the air tends to remain stationary or stagnate. This can often be remedied by using a fan to churn the air and set it in motion. Air in motion has a greater cooling effect than stationary air of the same temperature or even a few degrees lower. This is easily seen by the effect of turning on an electric fan in a room. No change in temperature results, although the surroundings, even though not in the blast of the fan, seem much cooler. It seems to vitalize the air by putting it in motion. Rooms where the circulation is bad can often be improved by adding a fan or two to redirect the air currents and give more widespread circulation. If the construction of the room and location of the inlet and outlet ventilating ducts are not in the best position for proper ventilation, as is shown in accompanying sketches, showing five cross-sections of a room, a propeller fan properly located can help overcome the construction difficulties.

Fans are much used in industry to overcome so-called "hot spots" around some machine or process. In these cases the fans are usually set so as to pull the air away from the workers and allow it to be replaced by the air in the room. Sometimes the air is blown directly upon the workman. Care must be exercised in placing the fan to see that it does not suck the hot air from furnaces past the workers or direct the draft toward the furnace. The best location is found by experiment, as it is dependent upon the arrangement and surroundings. Frequently "hot spots" are cooled by a blast from a duct where the air is brought in from the outside.



The relation of the air currents to the inlets and outlet.

One of the first steps in any ventilation problem is to trace the path of the air currents. This sketch, which is self-explanatory, indicates the effect of various placements of the inlet and outlet. Best practices place the inlet either on the floor discharging upward or above the level of the head. Propeller fans are often used to redirect the air currents into stagnant spots.

The most common methods of ventilation are by:

1. The vacuum method, which consists of exhausting the air from a room;
2. The plenum method, which forces the pure air into a room; and,
3. A combination of the two methods.

Ventilating by the Vacuum Method

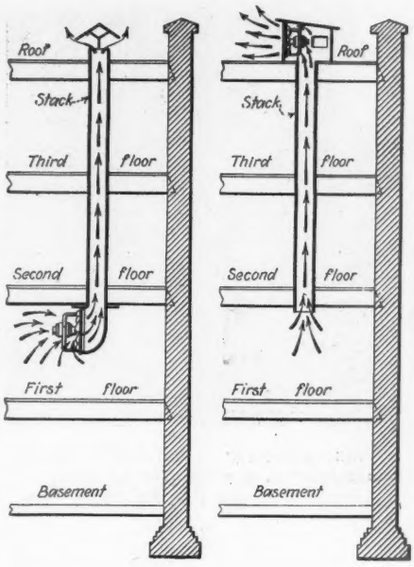
In ventilation, as in many other lines of work there is a one best way for each individual ventilating problem, but not any one method which is best or usable for all industrial problems. The vacuum method, for example, pulls the impure or contaminated air out and allows the partial vacuum created to be equalized by atmospheric pressure. The air enters through doors, windows, special inlets and even by seepage through the walls and around doors and windows. For this reason the vacuum method is generally best adapted for removing heat, fumes, odors, steam or any other impurity which it is desired to keep out of circulation in the air. The suction may be concentrated at the spot where the impurity or heat originates by a hood or other means, as already described in connection with gravity systems. For that matter, a gravity system is a vacuum system operated without the use of power.

In many industrial processes, as when collecting dust or heavy vapors, natural draft is not sufficient or does not "draw" fast or hard enough and exhaust fans or blowers are

added in the exhaust pipe. This makes it unnecessary for the exhaust pipe to extend vertically through the roof, as several hoods may be connected to one horizontal pipe, either above or below the level of the hood, and be led off through the exhaust fan or blower, and so take care of ventilation in the lower floors of a multi-story building. Dust, shavings and similar materials must be exhausted into some form of dust collector, where the solid particles are allowed to settle and the air is exhausted. Gases and fumes are usually exhausted into the air, although in some processes these are treated to give valuable by-products. Acid fumes must be treated before freeing.

Sometimes, especially when the whole room must have the air changed, the exhaust fan employed does not require a hood. Examples of this may be found in the factory restaurant and kitchen (special exhaust hoods with fans are placed over stoves and steam tables, however), work rooms where no disagreeable fumes, dusts or odors are created, wash and locker rooms, and similar places where general ventilation is sufficient.

Propeller fans located in the wall or occupying a part of the window space are often used under these circumstances. The performances and capacities of various sizes of propeller fans are given in Table 2. However, the two main problems in connection with the maintenance of propeller fans are: The protection of the motor from moisture, steam, or in some cases corrosive fumes; and the replacement of bearings.



Two methods of placing the exhaust fan relative to the duct.
While this shows a propeller fan the same arrangement may be used with an exhauster or blower. The prevailing direction of wind must be taken into account when placing the outlet.

Each manufacturer has his own method of protecting the motors which, usually, must be of the inclosed type. In general, the protection consists of some method of ventilating the motor by circulating inside the frame air which is not contaminated or heated. Also the air flowing past the motor has some radiating effect unless of high temperature. The fan motor must be so constructed as to give opportunity for frequent inspections of the commutator and observations of the condition of the windings. Due to dust, and often continuous operation of the fan, bearings are given hard service. As practically all the trouble from any means of mechanical ventilation comes in one or both of these places, they should receive the greatest attention when installing new equipment. With proper attention, particularly to oiling, a fan or blower should give almost no trouble unless under specially hard service.

In multi-story plants where it is not possible to exhaust with a propeller fan through the wall or a window, the air from the various rooms is drawn into a common duct, discharging into an exhauster, which is usually placed on the roof. Several vertical risers may be served by one exhauster.

Table 2—Performance Data on Propeller Fans

Direct Current				Alternating Current							
				25 Cycles—Single Phase				60 Cycles—Single Phase			
Fan Dia. Inches	Cu. Ft. Air per Min.	Watts per Hour	R.P.M.	Fan Dia. Inches	Cu. Ft. Air per Min.	Watts per Hour	R.P.M.	Fan Dia. Inches	Cu. Ft. Air per Min.	Watts per Hour	R.P.M.
12	1100	70	1700	16	1800	130	1420	16	1900	100	1200
16	1900	90	1200	18	3500	190	1420	18	2200	125	850
18	2530	110	1000	20	4700	240	1420	18	3240	180	1140
18	3100	160	1100	24	6000	290	720	20	3300	180	850
20	3590	198	900	30	9400	500	720	20	4300	240	1140
24	6300	275	800	36	10000	520	490	24	5800	280	690
30	9200	440	700	42	17800	800	490	24	7000	300	850
36	12500	560	600	Two and Three Phase				30	7600	400	565
36	14600	770	700					30	9100	500	690
42	18000	880	500	18	3500	210	1420	36	10000	600	490
48	23400	1320	450	20	4700	240	1420	36	12000	800	565
54	28500	1780	400	24	6000	290	720	42	17800	1200	490
60	33600	2270	360	30	9400	500	720	Two and Three Phase			
72	44800	2880	270	36	10000	520	490				
				42	17800	800	490	18	3240	180	1140
				48	26200	1200	490	20	4500	200	1140
				54	28000	1600	360	24	5800	240	690
				60	36000	2050	360	24	7000	280	850
								30	7700	325	570
								30	9000	400	690
								36	10000	520	490
								36	12600	600	570
								42	17800	800	490
								48	26200	1400	490
								54	29600	1800	420
								60	38000	2200	380
								72	48000	2800	285

An idea of the power consumed to deliver any volume of air is shown in this table. These fans usually operate against a low back pressure. Blowers and exhausters forcing air through ducts operate against a back pressure and the power required is dependent upon the volume, velocity and the back pressure. Where two diameters are given consecutively the first refers to the standard fan, the second to a special high-speed fan.

Power Requirements in Ventilation

Many attempts to get more work out of a fan are disappointing because of a failure to recognize the relation of the power required to the work done. In handling air the pressure varies with the square of the velocity, and the work done (or power required) varies with the cube of the velocity. The pressure is dependent upon the resistance (size, smoothness and length of the inlet and discharge ducts), and the velocity upon the speed of the fan. Thus, doubling the speed of the fan quadruples the pressure (if within the capacity of the fan) and increases the work done (or power required) eight times. Ordinarily the velocity of the air in a blower is the same as the peripheral or fan blade tip speed.

In determining the power required to force air through a duct the length, diameter, bends and character of the inside of the duct must be considered. A fan traveling at a definite speed will deliver practically a definite quantity of air against a constant resistance. However, the speed of the fan and the power required to force this air through the duct will vary as these factors already mentioned add to the resistance of the passage of this air. The resistance always bears a definite relation between the length and the diameter of the pipe or duct and all other contributing factors are transformed

into units of length and diameter. For example, an elbow is considered to add a resistance equivalent to that of a length of straight pipe equal to 10 times the diameter, or, as it is commonly called, 10 diameters of pipe. Approximately 50 diameters of pipe or its equivalent will cause a resistance equivalent to the velocity head, which must be made up by applying greater power to the fan. For example, 40 ft. of 12-in. duct with one elbow, total an equivalent of 50 diameters long and would have one velocity head resistance. Supplying air at 2,000 ft. per min. would give a velocity pressure of ¼ in., which, added to the equivalent resistance pressure, ¼ in., would give a total resistance pressure to overcome of ½ in., or the total of the velocity head plus the resistance head. The power required, and the size of the fan, would depend upon the style, speed and other factors which could best be obtained from the manufacturer of the fan. A change in any of these might overload or underload the fan, as has already been explained.

In laying out an exhaust duct line the main duct should have 20 per cent more cross-section area than all the ducts entering the main duct up to that point. All enlargements should be on a taper and never abrupt. This additional 20 per cent decreases the resistance of the duct and so saves on the power. Also branch pipes should enter the main ducts at an angle not exceeding 45 deg. and be inclined in the direction of the flow. All bends and elbows should have a radius in the throat of from 1½ to 2 times the diameter of the pipe.

This exhauster is handling carbon dioxide gases at the Bevo plant of Anheuser-Busch Co., St. Louis, Mo.

Fumes, gases, or mildly corrosive vapors are handled through cast-iron exhausters which, if high speed, may be direct connected. Low-speed exhausters are usually driven by belt. For highly corrosive acid fumes exhausters or ducts made of, or lined with, special acid-resisting metals may be used. If the cast-iron equipment will last about two years under this service the common practice is to replace it with a new outfit rather than get the more expensive, non-corrosive equipment.

The exhausting power of any suction line, such as is connected to an emery or buffing wheel, depends upon the suction maintained. Factory inspectors usually test out a line to see if this suction is sufficient. In Illinois, for example, the duct must carry the air at a velocity of 9,000 ft. per min. This is tested out by removing a hood at a machine, covering the opening with cardboard and inserting a rubber tube connected to a U-tube filled with water. Five inches of water must be displaced. This is a larger displacement than is required in most states, however. Some of the causes which might show a decreased suction are:

1. Adding duct or bends to the exhaust duct beyond the exhauster.
2. Increasing the number of inlets, such as adding another machine, without increasing the speed of the fan.
3. Adding to the length of the inlet duct, adding bends, etc.
4. Accumulations in the bottom of the ducts or other obstructions.
5. Open joints, punctures or other similar openings.
6. Decreasing the speed of the fan.

Wherever additional openings are placed before the exhaust fan, or length or resistance removed beyond the fan, it increases the load which is dependent upon speed and air delivery. As the power required increases with the cube of the load, an exhaust fan can easily be overloaded by any change in the ducts which will add more air to be handled. Constant speed motors or other equipment driving at a fixed speed prevent adding to the load by speeding, but supervision is the only means of preventing overloading by permitting more air to be handled by the fan. Adding a damper or cut-off in the suction at each machine to stop off that machine when it is idle decreases the air handled, and so the load, and saves power.

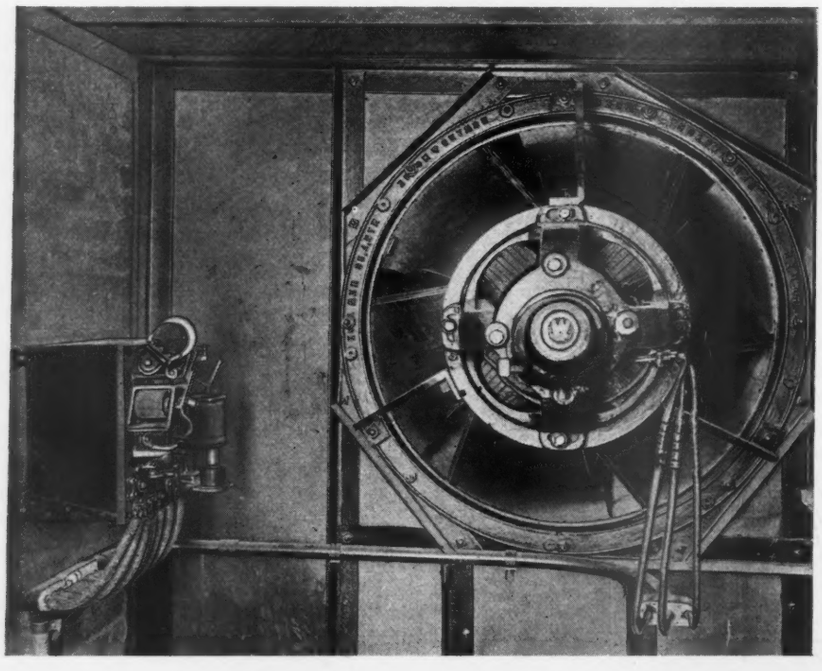
Ducts in exhaust system are usually made of galvanized sheet metal. Ordinary practice requires that elbows be made at least two gages heavier than the rest of the duct. The practice recommended by one manufacturer of exhaust equipment is as follows:

Diameter of Duct	Gage No. of Sheet Metal
30 in. and up	18
21 to 30 in.	20
8 to 20 in.	22
8 in. or less	24

In riveting straight seams and elbows, good practice specifies tinned rivets on 2½-in. centers. All ducts should have at least 1-in lap at joints with the lap in the direction of the flow of air, so as to give a smooth pipe or duct (*Continued on page* 406)

Another type of wall fan.

This fan is operated by push-button, remote control. In many industrial processes the motor must be of the enclosed type to protect the winding as all air or fumes is pulled past and through the motor.



TOTAL ABSENCE of motor failures in a steel mill is an ideal to be worked for, but so far it has never been realized. Due to the severity of service and the peculiar operating conditions, a certain percentage of failures must be anticipated. In this article Mr. Whitcomb shows the importance of keeping a detailed record of these failures and how a careful analysis of them has made it possible for the maintenance man to devise ways to reduce them in a large mill that operates 900 auxiliary motors ranging from 1/12 to 300 hp. on a wide variety of applications.

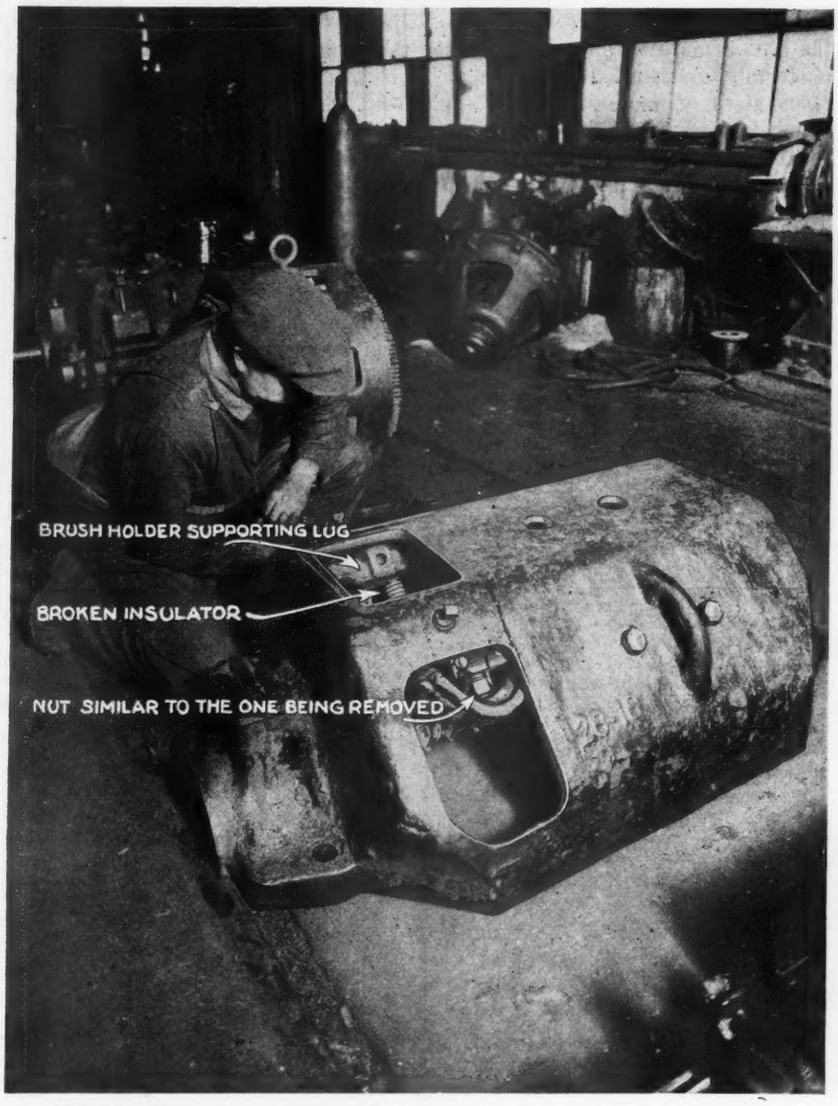
Some of the Wheres and Whys of

Steel Mill Motor Failures

And Ways the Maintenance Man Can Reduce Them

By ARTHUR J. WHITCOMB

Electrical Department, The Steel and Tube Company of America, Indiana Harbor, Ind.



A brush holder support is being removed to replace a broken insulator. While dismantled this motor was painted on the inside and had new bearings installed

WHILE there are many causes of motor failures, probably the most flagrant are those of misapplication of the motor and its control. There is only one remedy for this sort of failure; namely, the correct type of motor must be used and the control for the motor must be suitable for the service under which the motor operates. Other main causes of motor failure are:

(a) Overload, due to increased production.

(b) Dirt and corrosion.

(c) Normal wear.

(d) Defects in motor design.

In a properly designed mill, most failures will result from the first three causes.

Granting that a certain number of failures are likely to occur, it is of interest to know where they are most likely to happen and what proportion there is likely to be of each kind of failure. An analysis of these failures is of interest, first to the motor inspector, so that he may know what parts to watch the closest; second, to the storekeeper, in order that he may keep an adequate supply of the parts most needed; third, to the electric repair shop, so that they may properly keep available facilities for the repair of motors on which failures occur most often; and fourth, to the electrical superintendent, in order that he may have a grasp of the number and variety of failures and may be able to compare the failures of one period with those of another.

The purpose of this article, therefore, is to give some data on motor failures, which has been collected by the writer, and to suggest ways of classifying this data so that definite conclusions can be drawn. The data presented has been obtained in a steel plant having approximately 900 auxiliary motors, ranging in size from 1/12 hp. to 300 hp. There are about 465 mill type motors, 260 d. c. open type motors and 175 a. c. open type motors actually in operation. The data has been grouped and classified in several arrangements, as shown in Tables I, II, III and IV, so as to bring out pertinent facts regarding the failures.

Table I shows the alternating current motor failures classified according to the nature of the failure. In Table II the direct current motor failures are classified in a similar manner.

Since 49.3 per cent of the total a. c. motor failures occurred in the stator winding and 58.1 per cent of the total d. c. motor failures occurred in the armature winding, it is of interest to note how these failures are distributed over the different sizes of motors, as given in Table III.

With the exception of four items, the d. c. armature failures are quite uniformly distributed over the various sizes of motors. The 15-hp. armatures account for 27.9 per cent of the failures. This is due to a faulty control application, as will be shown later. The percentage of 6, 20 and 30-hp. enclosed type motor armature failures is high. This is due to the large number of these sizes of motors as compared with the number of motors of the other sizes. With the exception of the 5-hp. size, the a. c. stator failures are quite uniformly distributed. The failures on the 5-hp. size are accounted for by the peculiar gas, steam and dust conditions surrounding these motors.

The previous tabulation gives an idea of the extent of the different kinds of failures and their distribution over the different sizes of motors. The electrical superintendent will want to know on what applications most of the failures are occurring, the probable cause of the failure and the relative proportion of the total failures that fall on each individual drive. This information is tabulated on page 380, Table IV.

The third column is important, since it gives the ratio of the motor failures to the number of motors on similar drives; that is, the failures per motor. A ratio of unity would mean one failure for each motor which is on a similar drive. Combined with the percentage of total failures, these two values give a convenient way of comparing the failures of one period with those of another. Also, they give a means of knowing the relative importance of each application's failures. For instance, the first application has 7 per cent of the total failures and only ¾ of a failure per motor, while the fourth and fifth applications have 5.4 per cent of the total failures and 4.5 failures per motor. Obviously, the first application is having failures which, while not so important of themselves, are important in the aggregate because there are so many similar drives that they form a large part of the total failures. The fourth and fifth applications' failures, while not forming as large a percentage of the total, are important because of the large number of failures per motor. Tests and investigations of these applications showed that the wrong type of control was being used on the first application. It was found that full automatic control would practically eliminate this trouble. Tests on the fourth and fifth applications showed that the loads were too severe for the size of motor being used. The size of the product had been increased without increasing the size of the motor. This resulted in overloading the motor whenever the larger product was going through the mill.

A motor with a weakened or damaged part cannot be depended upon to carry its full share of the burden when the peak of production demand is met, and if many motors are in poor condition the entire plant may fail in an emergency. A fixed plan of inspection and repairs is therefore essential to make certain that every motor is ready for its duty. Small motor maintenance in the

Analysis of Failures of A. C. and D. C. Motors

Table I—A. C. Motors

	Per cent
Stator grounded	26.5
Stator open and shorted	19.0
Stator roasted	3.8
Total stator winding failures	49.3
Rotor shorted	5.1
Rotor open	3.8
Rotor grounded	2.5
Rotor roasted	1.3
Rotor slip rings grounded	1.3
Total rotor winding failures	14.0
Bearing trouble	24.0
Base loose	5.1
Laminations loose	2.5
Rotor shaft bent	2.5
Keyway worn	1.3
Slip rings worn out	1.3
Total mechanical failures	36.7
Total a. c. motor failures	100.0
Slip rings grounded	1.3
Slip rings worn out	1.3
Total slip ring failures	2.6
Total failures in stator and rotor windings	63.3

Table II—D. C. Motors

	Per cent
Armature shorted	34.0
Armature grounded	16.7
Armature open	6.6
Armature roasted	0.8
Total armature winding failures	58.1
Commutator rough or grooved	5.8
Commutator shorted	1.6
Commutator grounded	1.6
Commutator leads loose	0.8
Total commutator failures	9.8
Interpole field grounded	5.0
Interpole field roasted	1.6
Series field roasted	4.1
Series field grounded	3.3
Series field shorted	0.8
Total field winding failures	14.8
Bands loose	6.6
Bearing trouble	5.8
Pole pieces loose	2.5
Keyway worn	1.6
Shaft broken	0.8
Total mechanical failures	17.3
Total d. c. motor failures	100.0
Total winding failures	72.9

Things the Data in Tables I and II Show

[1] In steel mill drives 63 per cent of all a. c. motor failures and 73 per cent of all d. c. motor failures occurred in the stator and rotor windings. Most of the a. c. failures occur in the stator winding and most of the d. c. failures occur in the armature winding. Approximately 50 per cent of the motor failures occur in one or the other of these places. This indicates the need of having a complete supply of coils on hand, either made in the coil winding section of the shop or else bought from the manufacturer. They give a relative indication of the amount of labor required in the shop for making coils and for rewinding motors.

[2] It will be noticed that for a. c. motors the largest individual item is grounded stators, with a value of 26.5 per cent, and that for d. c. motors the largest item is for shorted armatures, with a total of 34 per cent.

[3] Mechanical trouble runs high for the a. c. motors as compared with the d. c., the proportion being 36.7 per cent for the former and 17.3 per cent for the latter. This is caused by the large amount of bearing trouble (24.0 per cent) experienced on a. c. motors. Due to the narrow air gaps on this type of motor, less bearing wear is permissible and consequently bearings must be changed much more frequently. It is of interest to note that the bearing trouble on d. c. motors is approximately one-quarter of that for a. c. motors. The large proportion of bearing trouble indicates the value of having a machinist in the electrical repair shop. His time can be profitably spent machining bearing shells, babbitting them and machining brass and bronze bushings.

[4] There is four times as much commutator trouble as there is slip ring trouble. This is quite natural if the construction of the two is considered. However, if only the items which require the disassembling of the commutator or slip rings (such as rings worn out or grounded or shorted) are considered, it will be found that each has approximately the same percentage of failures.

Mark plant of the Steel and Tube Company of America is based on an organized plan of inspections conducted while the apparatus is running. In this article the term "small motor" is used as it is employed in steel mill work, where motors run into very large sizes, and refers to motors of 300-hp. rating or less, of which there are nearly 1,400 in this plant.

The inspection work is done by the motor inspectors and their helpers, under the direction of a chief inspector. One motor inspector and one helper are assigned to each mill.

Daily and Weekly Routine Duties of Inspection Force

Each morning the helper blows out the motors and their control equipment with compressed air and at least twice each day the inspector gives each motor a thorough examination. He first inspects the commutator, and if the brushes are not sparking he knows that it is satisfactory. If there is appreciable sparking, he endeavors to find out whether it is due to brush trouble, open circuits in the winding, or commutator trouble, such as grooving, high or low bars, or high mica. If the commutator is blackened, discolored or rough, he grinds it with a commutator stone while the motor is in service. If there is trouble in the winding he changes armatures and sends the damaged one to the repair shop. If there is brush trouble, new brushes are put in or the old ones resurfaced at the first opportunity.

Bearings are next examined for signs of heating. The oil rings are looked at to see that they are revolving freely and that the motor has plenty of oil. Special attention is given to see whether the bearings are worn. This is most easily determined by watching the shaft when the motor is reversing. If it jumps, this is an indication that the bearings are worn. The motor itself is examined for overheating by feeling of the interpole, shunt, and series field coils, on open-type d. c. motors. With the enclosed types the hand is inserted in the hand hole. On a. c. motors the stator laminations and stator coils are felt to detect undue heating.

The motor is then examined for vibration. This may be caused by worn pinions, misalignment of pinion with gear, loose end bells, loose foundation bolts, loose motor base, or by trouble in the drive to which the motor is applied. This vibration must be eliminated or a motor failure is sure to result.

A weekly inspection of air gaps is made on the open-type motors by means of a thickness gauge. About once a month, when the mill is down for a day or two and there is little

Table III—Comparisons of Failures for Different Sizes and Types of Motors

Per Cent of Total D. C. Armature Failures	*Hp. Rating of Motor and Type*	*Per Cent of Total A. C. Stator Failures*
1.5	½ open type	...
1.5	2½ open type	...
...	3 open type	6.5
...	5 open type	41.3
2.9	5½ open type	...
4.4	7½ open type	10.9
4.4	8½ open type	...
...	10 open type	6.5
5.8	12 open type	...
27.9	15 open type	2.2
7.4	25 open type	...
...	30 open type	4.3
...	40 open type	10.9
...	50 open type	10.9
...	75 open type	6.5
11.8	6 enclosed type	No enclosed type A. C. motors are used.
4.4	12 enclosed type	
13.2	20 enclosed type	
7.4	30 enclosed type	
1.5	40 enclosed type	
1.5	80 enclosed type	
2.9	90 enclosed type	
1.5	150 enclosed type	
100.0		100.0

Fitting a new bearing on a mill-type motor.

Bearings should always be carefully fitted to be sure that they provide a full wearing surface. The operator is rocking the bearing on the shaft in the lower illustration to locate the points of contact after a preliminary scraping as shown above. When motors are taken to the shop they are given a thorough overhauling. Whenever new parts can be supplied to improve the unit they are used. It costs but little to fix up the bearings when a motor is dismantled in the repair shop.

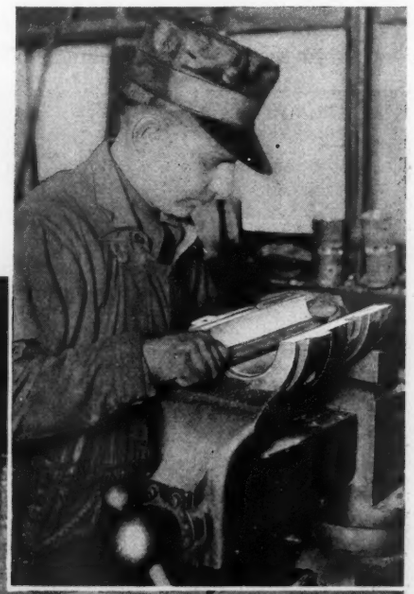


Table IV—Causes of Failures for Different Kinds of Motor Applications

Application	Per Cent of Total Failures	Ratio of Motor Failures to Total Motors on Similar Drives	Cause
I	7.0	0.75	Wrong type of control.
II	6.0	1.25	Service conditions and overloaded
III	5.4	9.0	Wrong type motor and overloaded
IV	5.4	4.5	Overloaded, undersized motor
V	5.4	4.5	Overloaded, undersized motor
VI	3.6	1.5	Worn out motors
VII	3.0	5	Overloaded motor
VIII	3.0	5	Control fault
IX	1.8	3	
X	1.8	3	
XI	1.8	3	Mechanical trouble external to motor
XII	1.8	3	Overloaded, mechanical trouble external to motor
XIII	1.8	3	Overloaded
XIV	1.8	3	
XV	1.8	1.5	Control trouble
XVI	1.8	0.5	
XVII	1.8	0.5	
Drives having only two failures	12.0		
Drives having only one failure	33.0		
Total	100.0		

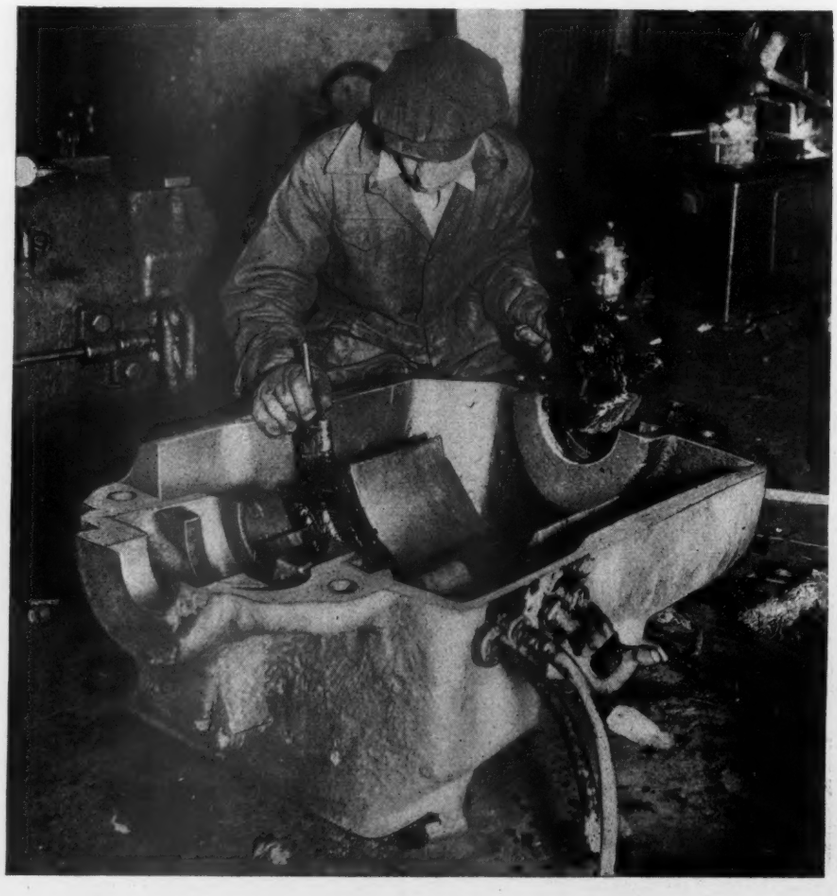
dust in the air, the open-type motors are given a coat of paint. Most of the painting of the inside of enclosed motors is done in the shop when the motor is given a thorough overhauling.

Minor Repair Work Done by Inspectors

Motor inspectors make some of the minor repairs. Brush replacements or refittings are made on the job, also commutators are ground with stones, provided they are not in such shape as to require turning and slotting. Brush holders are also changed and repaired while on the job, and armatures and pinions are usually replaced without taking the motor to the shop. A motor damaged otherwise than as described above is replaced with a complete spare unit and the damaged motor is loaded on a small car that runs on the plant railway and taken to the repair shop for necessary repairs and a general overhauling.

The electrical repair shop makes all major electrical repairs on motors, controllers and resistors, and in addition, makes coils, bearings, shafts and other miscellaneous items. The work varies from time to time, hence it is necessary to assign men to the different classes of work, according to the amount on hand and the necessity for immediate repair of each kind of apparatus. As a general rule, however, the motor repair work requires most of the time of one winder, two helpers, one machinist, and the occasional services of a welder. The bulk of the motor repair work is winding armatures, stators and rotors. This requires many coils. These coils can be made in the shop or bought from the manufacturer. What coils should be wound in the shop and what coils should be bought is a question that puzzles many operators. The answer depends on how many motors of each size and type there are in the plant, how frequently breakdowns occur and upon the investment required for the coil winding machinery for the different sizes. In the Mark plant the following limits have been set for making coils in the shop. The sizes and types not mentioned in the following list are bought from the motor builder.

(1) Armature coils for open-type constant and adjustable speed a. c. motors up to and including 15-hp. rating.
(2) Armature coils for enclosed mill type series and compound variable speed d. c. motors, up to and including 30-hp. mill rating.
(3) Induction motor stator coils for motors of 75 hp. or less, except those for 2,200-volt motors.



Painting coils in lower half of motor frame.

A heavy coat of black insulating paint is applied to the windings of motors taken to the shop for repairs. This painting keeps moisture and dirt out of the motor windings and greatly prolongs their life in hard service.

The coils listed cover 95 per cent of the coils needed for the routine motor repair work, the other 5 per cent, which includes induction motor rotor coils and all field coils, are bought, for the reasons heretofore given. Either a full set or a partial set of coils is carried in stock for every motor in the plant. All of the coils listed above as being made in the shop are wound on a "Segur" coil winding machine and are then formed in a coil spreader. This coil winding machine has adjustable spools, so that any desired size of coil may be wound, provided the copper is not too heavy for the machine to handle.

Open-type d. c. motor coils and all stator coils are wound with double-cotton-covered magnet wire, dipped in baking varnish, and baked for at least 24 hours. The coils for the enclosed mill-type motors are wound with asbestos-covered wire—usually "Deltabeston" wire is used. The coils are further insulated with mica and asbestos tape, but they are not dipped or baked.

Turning and Slotting Are Chief Commutator Repairs

Most of the commutator repair work consists of turning up in a lathe and slotting. Sometimes the bars become loose, in which case the V-rings are tightened before turning in the lathe. Occasionally the V-rings "ground," which necessitates the installation of new rings. There are many cases in which the mica breaks down between bars. Commutator cement can be used for filling the spaces between bars when sufficient time can be allowed for it to dry, but for rush jobs, dental cement is used. Sometimes the bars are so badly damaged that it is necessary to partially disassemble the commutator and replace the defective bars as well as put in new mica segments.

On squirrel cage induction motors the individual bars often break off at the short-circuiting ring of the rotor. These are usually rewelded to the short-circuiting rings by oxy-acetylene welding, but sometimes it is necessary to replace the old bar with a new one.

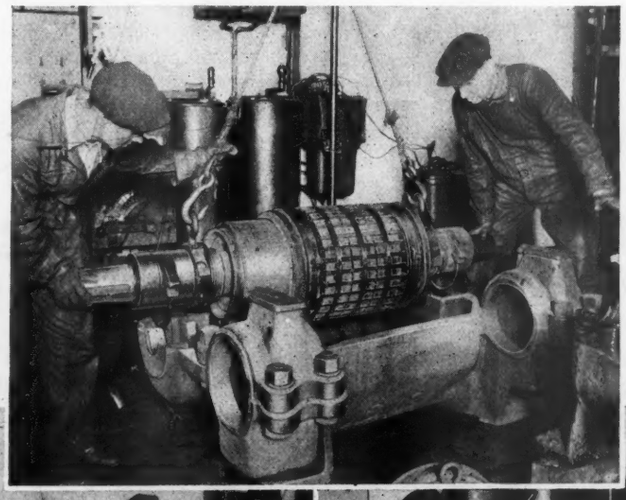
Wound rotor repair consists of rewinding the rotor and repairing the slip rings. Most of the trouble experienced with slip rings is due to uneven wearing, grooving and wearing out of round. After being trued up in a lathe a few times the rings become too small in diameter and it is necessary to replace the old rings with new ones. Most of the wear on slip rings can be prevented, however, by proper brush application. Sometimes the rings "ground" through the action of the graphite dust in the mills, requiring new insulation for the rings.

Motors Subject to Mechanical Wear and Failure

The main damages to motor shafts are worn keyways, worn journals, and broken shafts. If the keyway is worn, a new one is cut 90 deg. further round the shaft. If this has already been done, or if the end of the shaft is battered, it is built up all around by welding and then is turned and slotted the same as new. In the case of worn journals or broken shafts it is considered cheaper to replace the damaged parts with new ones. The shop is provided with drawings of all the shafts in use, and from time to time new ones are made up. On some severe applications considerable shaft breakage has been experienced on the enclosed mill-type motors and it has been necessary to replace the original shafts with new ones made of special heat-treated steel.

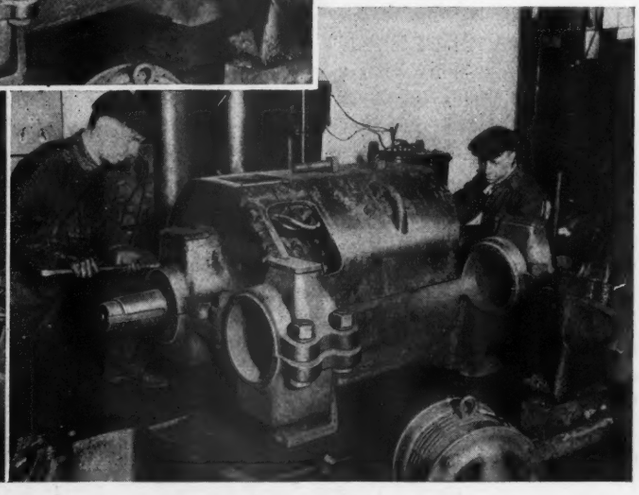
Numerous repairs are made on motor frames. On induction motor stators the chief troubles occur in the windings, with "grounds" and "opens" predominating. Occasionally the key holding the stator laminations in place loosens and permits excessive vibration. The key soon wears under such conditions until restacking of the stator is necessary. Frames having a separate pressed-steel base riveted

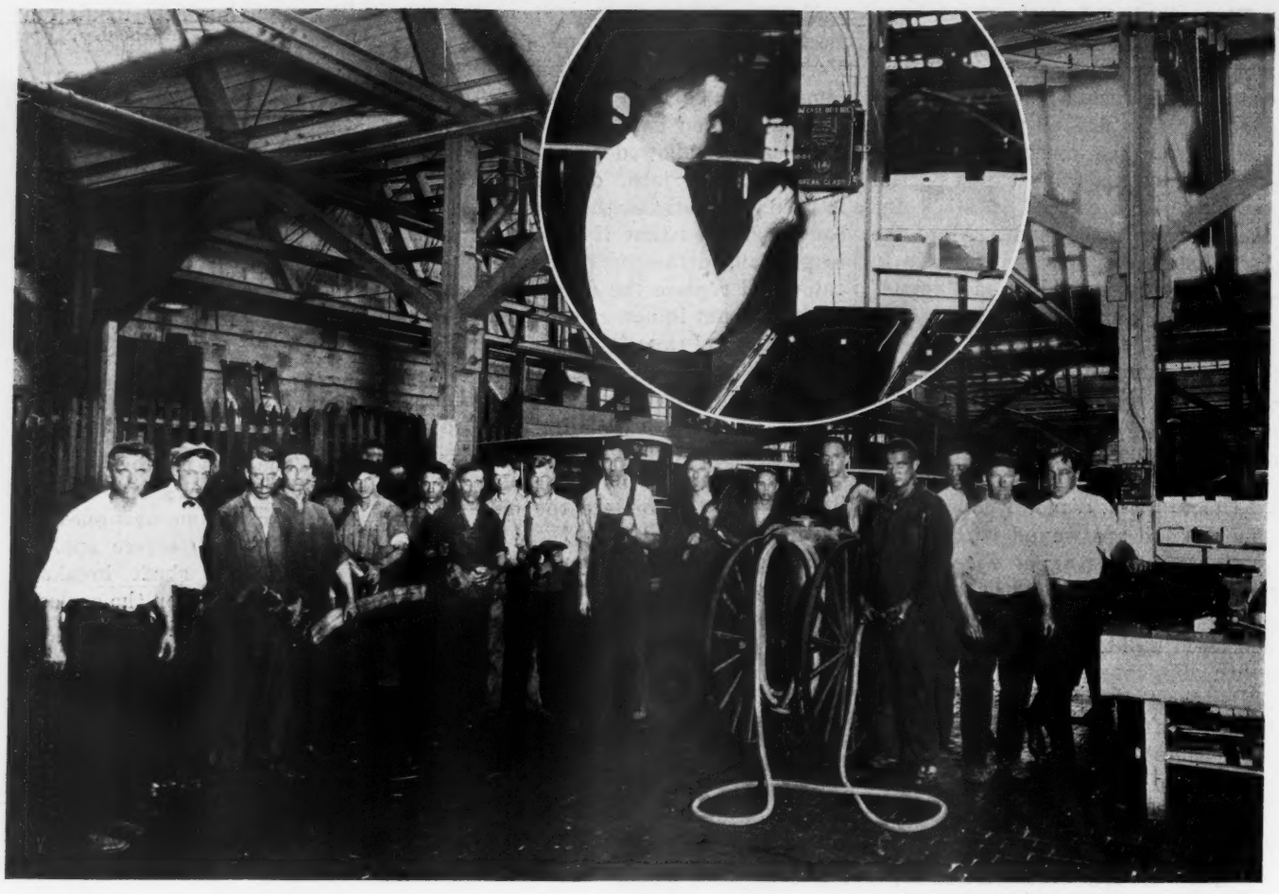
(*Continued on page* 409)



Replacing armature in motor frame.
The armature is put in place with the bearings attached. Bearings are first fitted to the shaft and then to the motor frame. In this case it was necessary to make a slight alteration to make the bearing come just right in the frame.

Lowering top section of mill-type motor over armature.
The top section of the motor frame is then lowered into place after the coils are painted and the bearings finished in proper manner. When the hand-hole cover plates are attached this motor is ready for another six months or year of service.





An alarm of fire turned in at a call station such as shown in the circular inset brings out the full force of fire fighters and equipment in 40 seconds.

Some Practical Pointers Dealing With the

Operation of Fire Alarm Systems

And Details of Some Changes That Were Made in Enlarging an Existing Installation

By J. ELMER HOUSLEY

Formerly Electrical Engineer, Aluminum Ore Company, East St. Louis, Ill.

THE EVER-PRESENT danger of fire carries with it so many possibilities of loss both in material and in production that some sort of a fire alarm system is essential in all industrial works. The most common form of electrically operated fire alarm system embodies the use of a closed circuit controlled by call or alarm boxes in accessible locations throughout the plant. Current flows continuously through this circuit, and means are provided in the alarm boxes to interrupt this current according to some selected code. As soon as the box is operated the interrupted current releases an armature on a relay. This armature is pulled back by a spring and makes another contact which may either complete a circuit to ring the fire gongs scattered through the plant, or may operate a larger relay controlling the gong circuit. The gongs are usually single-stroke bells and the code, corresponding to any alarm box, is heard throughout the plant. The location of the fire is thus made known at once.

Coding Alarm Boxes

Alarm boxes usually consist of a spring-driven mechanism, with a simple escapement for speed control, which operates a notched or ratchet wheel. The projections on this wheel open and close the main closed circuit in which all switches are in series. Various combinations of numbers may be formed by filing off certain teeth. For instance, if the wheel has fifteen teeth and the number eighteen is desired to be given by this wheel, then No. 1 tooth will be left, No. 2 will be filed off, No. 3 to 10, inclusive, will be left, and No. 11 to 15, inclusive, will be filed off. Thus there is a pause between the first stroke and the following eight strokes, and another pause before repeating the signal. The pause between calls, in this instance, is five times the length of the pause between the digits.

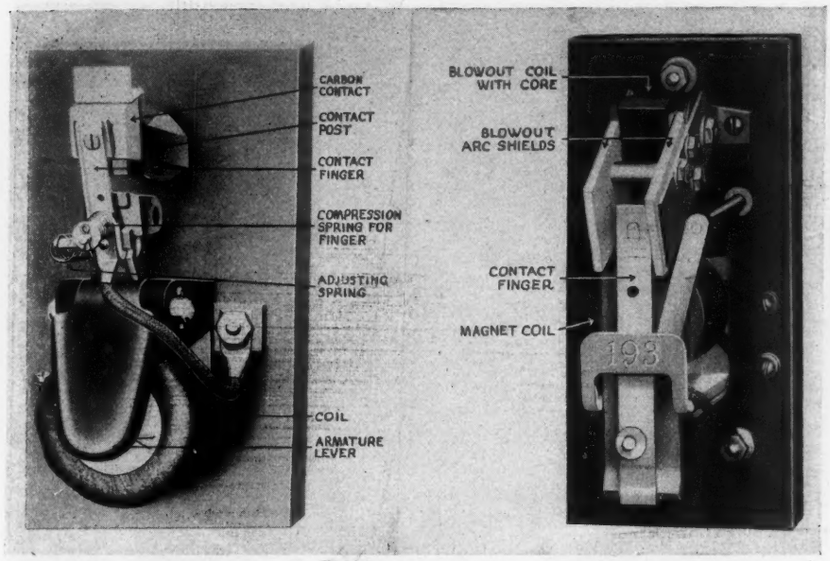


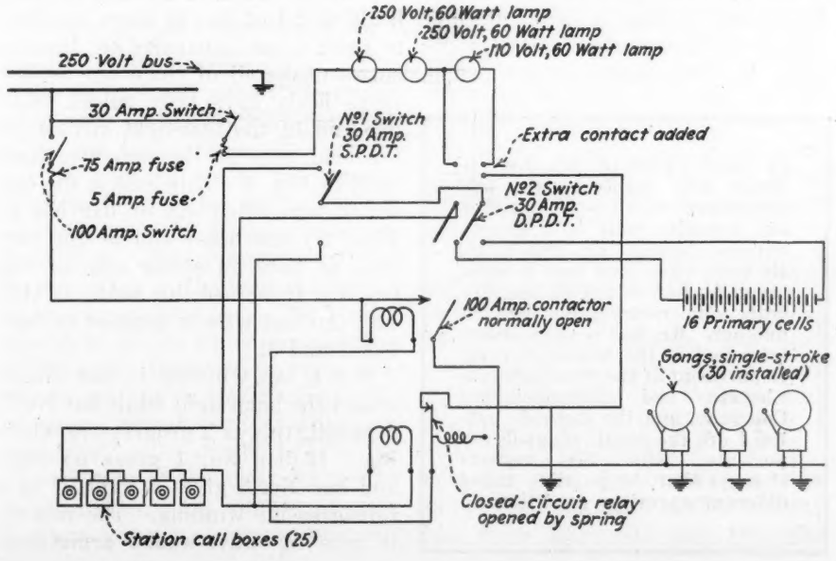
Fig. 1—Closed circuit relay (at left) which controls the operating coil of the magnetic contactor switch (at right) as shown in Fig. 2. These switches are made by Cutler-Hammer Manufacturing Co., Milwaukee, Wis.

The spring motor is usually designed to sound the call three times before running down. When the motor is rewound the mechanism is locked by a latch which is held in place by a small glass plate in the "break-the-glass" type of box or it may be a "pull-down-hook" on the inside of the case.

Source of Current Must Be Dependable

The current for the closed circuit may be provided by primary batteries of the Edison or other type, or from some dependable source of generated direct current. In the latter case a resistance must be used in the series circuit to cut the current down and low amperage fuses should be used where the circuit leaves the bus bars, in order to prevent damage in case of a short-circuit or grounding of the box circuit. The box circuit should be run with No. 8 solid copper weatherproof wire for outside work, and should be insulated the same as a 600-volt circuit. For inside work No. 14 BXL armored cable can often be used to advantage. Where Edison cells are used the resistance of the line should be kept as low as possible, since these give only about ½ volt per cell.

The relay used with the box circuit may be of the closed-circuit, telegraphic type, making a contact when its circuit is opened and thereby energizing the coil of a large magnetic switch which completes the circuit to the fire gongs. Dry cells are usually used with the telegraphic relay to operate the large magnetic switch. Another method is to use a larger relay on the closed circuit, with additional primary cells. This relay, being more rugged, may have heavier contacts, permitting as much as 250 volts to be used, instead of dry cells, to operate the large switch.


250 Volt, 60 Watt lamp
250 Volt, 60 Watt lamp
110 Volt, 60 Watt lamp
250 Volt bus
30 Amp. Switch
75 Amp. fuse
5 Amp. fuse
100 Amp. Switch
No. 1 Switch 30 Amp. S.P.D.T.
Extra contact added
No. 2 Switch 30 Amp. D.P.D.T.
100 Amp. contactor normally open
16 Primary cells
Gongs, single-stroke (30 installed)
Closed-circuit relay opened by spring
Station call boxes (25)

The gong-circuit is usually arranged for 110 or 220 volts direct-current operation, and is connected preferably in multiple, to permit changing the number of gongs in the circuit with greater ease than is the case with a series arrangement. The gongs are usually 12 inches in diameter and strike once each time the circuit is energized.

Remodeling a Fire Alarm System

Some time ago the writer found it necessary to enlarge a fire alarm system using a telegraph-type relay and five primary cells. The gong circuit used 250 volts direct-current, the negative side being grounded for traction service.

As originally planned, the new closed circuit comprised 8,000 ft. of No. 8 copper wire and about 30 gongs. A larger magnetic switch, having a rated capacity of 100 amperes at 250 volts D.C., was required in order to prevent the rapid burning of the contacts which would occur with the lower amperage switches. It was found that 1.8 amps., which was considered excessive for dry cells, would be required to operate the main switch. Consequently, the telegraph relay would require an intermediate relay with heavier contacts to control the operating current of the gong-circuit switch. This layout was rejected as being too complicated for reliable service; so an entirely new panel was purchased. (*Continued on page* 408)

Fig. 2—Alarm circuits showing switch arrangement for testing them out.

A—Normal operating position of No. 1 and No. 2 switches with box circuit on battery is No. 1 switch up and No. 2 switch down. B—When operating box circuit on 250 volts, with the box circuit shunted by 110-volt, 60-watt lamp, No. 1 switch is up and No. 2 switch up. C—To test box circuit for grounds, No. 1 switch is open and No. 2 switch up. Unscrew 110-volt shunt lamp. D—To make single stroke test ring—Pull No. 1 switch out of upper contact, then push back in, with No. 2 switch in either up or down position. E—To test control panel when box circuit is open, No. 1 switch is down and No. 2 switch either up or down. F—To test primary batteries independent of outside box circuit, No. 1 switch is down and No. 2 switch down. When the box circuit is being tested, the 75-amp. main switch should be pulled out to prevent confusion by ringing plant gongs. The results of tests may be watched on the closed circuit relay.

A. C. ROE Gives Details for

Cutting Out Coils in D. C. Windings

That Can Be Used to Make Quick Repairs

The armature winder is shown here testing to see whether the winding is of the progressive or retrogressive type

VERY often when a motor winding breaks down it is of the greatest importance to get it operating again without delay. One method of doing this is by cutting out coils. By applying a few simple principles the maintenance man will be able to save considerable money which would otherwise be lost from production being held up.

From the writer's observation of many motors received in the repair shop, it appears that accurate information on cutting out coils is not widely known or applied. A large number of the armatures received would have remained in service much longer if the first repairs had been properly made. In many cases armatures break down due to one weak spot in the winding. A slight repair will make the motor fit for a long period of service. Lap-wound armatures are not, as a rule, improperly cut out, but a great deal of trouble seems to be experienced on wave windings.

Approach the Trouble in a Systematic Way

The first step is to locate the trouble and determine its nature—whether the coil is short-circuited, open-circuited or grounded. Then find out if the armature is lap or wave wound, whether progressive or retrogressive and the lead pitch. Of course it is easy to tell a lap winding from a wave winding. The two leads from a lap-wound coil go to commutator bars which are adjacent to each other (see Fig. 1). The leads of a coil on a wave-wound armature are spaced apart a distance equal to twice the pole span (see Figs. 2 and 3).

After the trouble is located the next step is to determine whether the winding is progressive or retrogressive. In either kind of winding a progressive winding ends one bar ahead and a retrogressive winding ends one bar behind. It may be well to remember that a coil on a lap-wound armature ends one bar ahead or one bar behind its starting point. In a wave winding a series of coils (equal to the number of poles divided by two) encircles the armature, ending on the adjacent bar, either one ahead or one behind the bar started upon. It is for this reason that nine times out of ten when trouble occurs in one coil of a wave winding the coil or coils in series with it are damaged before the machine is stopped.

IN THIS ARTICLE Mr. Roe explains how speedy repairs are sometimes possible by cutting out defective coils in a direct-current motor or generator. He tells where and how to open the coils, how to put on jumpers from one commutator bar to another. Mr. Roe is shop superintendent of the Detroit Service Department of the Westinghouse Electric and Manufacturing Company, and the methods outlined are the result of much experience with the various changes that are possible under different operating conditions.

In order to find out whether the winding is progressive or retrogressive, remove three top leads from the commutator necks as shown in Fig. 5. These leads should be the top lead of the defective coil and two top leads ahead of it. If there are two or more wires in parallel per lead be sure to take all of them up. After these leads have been raised, hold one end of the test-light circuit on the lead next to the defective lead as B in Fig. 5. This lead is the one which was lifted out of bar No. 2. Then try the other end of the test wire to bars on either side of the bar that contained this lead. In this case the test wire is touched to bars No. 1 and 3.

For a lap winding if bar No. 1 makes the lamp light while bar No. 3 does not, this is a progressive winding. If bar No. 1 gives no light and bar No. 3 gives a light, it is a retrogressive winding. The reverse is true for wave-wound armatures.

If the bar ahead (bar No. 3 in this case) gives a light and bar No. 1 does not, this is a progressive winding. If the bar behind lights (bar No. 1) but bar No. 3 does not, then it is a retrogressive winding. This test may be tried upon any of the diagrams shown. For instance, take A of Fig. 2. If we raised the top leads from bars 1, 2 and 3 and hold one test wire on the top lead which came out of bar No. 2, then when bar No. 1 is touched with the other test wire the test lamp will light, indicating a retrogressive winding. When bar No. 3 is touched the lamp remains dark.

In making the test on the armature shown in C of Fig. 2 with the same top leads raised and the test wire connected on top lead No. 2, a light would be obtained on bar No. 3 which is one ahead of No. 2 and this indicates a progressive winding.

If readings are obtained that do not agree with those already mentioned, the top leads on bars No. 4 and 25 must be raised. For instance it might be found that when testing out from No. 2, bars 1 and 3 will both show closed circuits or both show open circuits. This might be the case if the winding was a four-circuit (double) series wave winding, which would mean that the winding ends two bars ahead or behind the one at which the start was made. If the two extra bars on the outside of the group of three are raised making five top leads raised from the commutator, then the circuit may be tested by putting the test lines across from top lead No. 2 to bars 4 and 25 respectively. If the bar ahead lights, then the winding is progressive; while if the one behind lights, it is retrogressive.

Cutting Coils Out of a Lap-Wound Armature

By finding out, as just described, where the leads of a lap-wound coil go to the commutator, it is easy to cut out this coil. The two commutator bars connected to the coil are short-circuited by jumping as shown in Fig. 1. This jumper is put on from one bar to the next at the rear of the commutator neck. The jumper should be of the same cross section as the lead. One, two or three coils can be cut out in this manner. On lap-wound armatures that are cross-connected, coils should be cut out on each side of the cross connection so as to balance the number of coils. If there are more coils on one side than on the other, circulating currents will flow. This means, for instance, that on a four-pole machine which had cross conections two coils should be cut out and these coils should be exactly on opposite sides of the machine. If it were a six-coil machine with three cross connections, three coils should be cut out at distances of 120 degrees apart from each other.

A Cut-Out Coil Must Be Opened

When cutting out coils on any kind of winding, always open the turns of the coil or coils which are cut out. This is necessary because

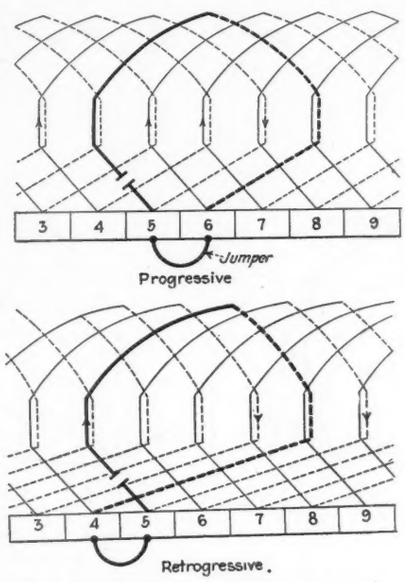


Fig. 1—How lap-wound coils are cut out.
The bars connected to the defective coil are short circuited by a jumper and the coil is opened.

if the insulation between the turns is weak the voltage generated in a coil may puncture the insulation and cause a short circuit which will burn out the coil and damage the coil adjacent to it. It is a fact that although the coil which has been cut out is disconnected from the commutator, it is still able to cause trouble if all of its turns are not cut open.

When the trouble is an open circuit or a short circuit in one coil only, the machine should be stopped before further damage has been done. If the mica between the commutator bars and the V-rings, etc., are in good shape, then the quickest way out of the trouble is to disconnect the bad coils from the commutator. Cut the leads and if the coil has more than one turn, cut the turns open, then put a jumper between the bars to which the coil is connected.

There is one condition under which a coil will not have to be cut open. This is when the mica between commutator bars has been short-circuited and carbonized. If this carbonization cannot be removed and repaired as told later on in this article, it may be jumped. The coil connected to the two bars should be cut out in the proper manner. If the coil is then tested and found to be perfectly good it is not necessary to cut it open. If, however, there is any doubt the turns must be cut open.

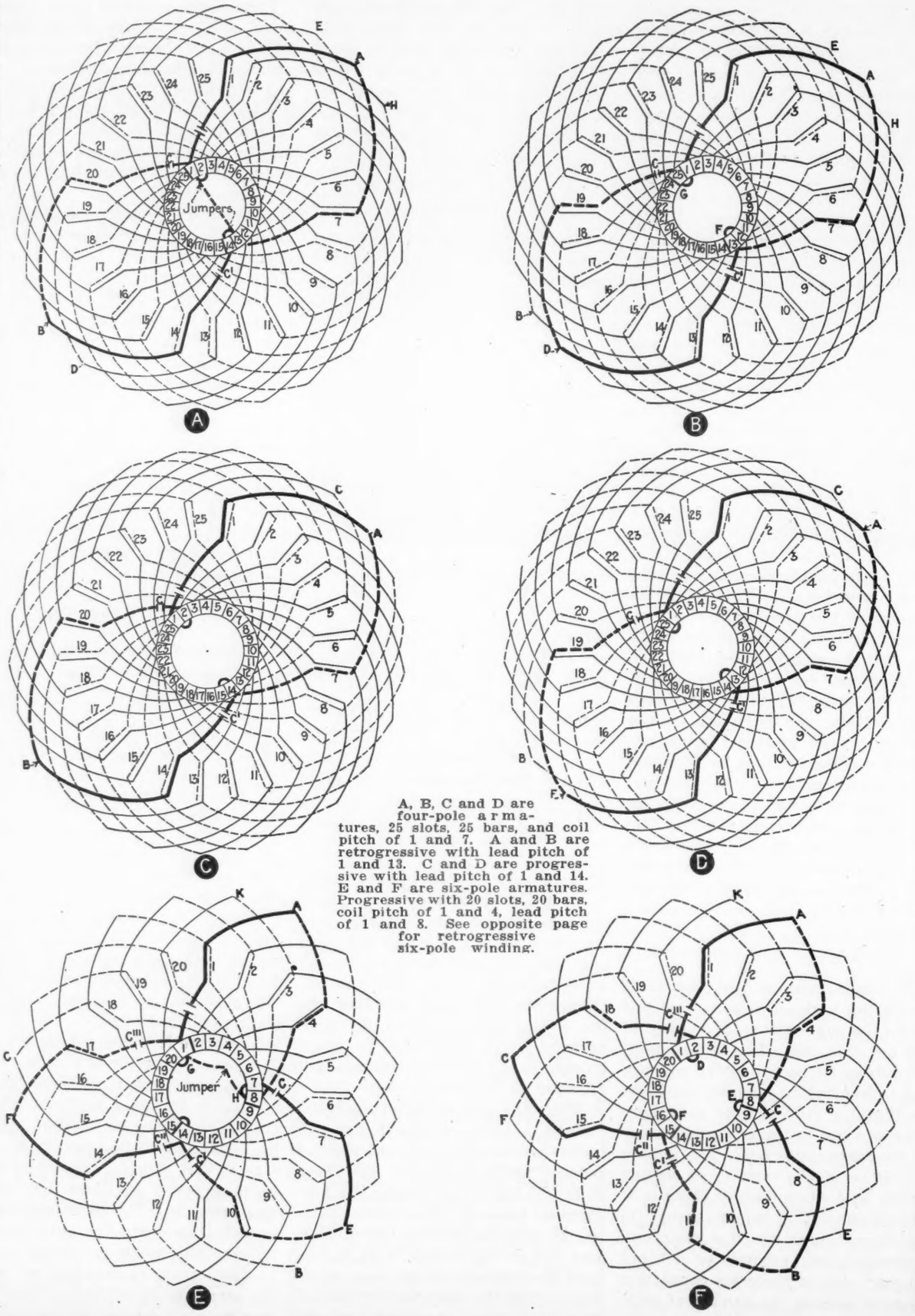
The best place to cut all the turns of the coil is at the rear end at the top half of the coil (See Fig. 4). Remove the tape and light out each wire if necessary to make sure that they all belong to the damaged coil. Using a pair of diagonal end cutters cut out about ⅛ in. of all the wires and then press them back in place with insulation between the two ends. No trouble will come from the wires in one section touching the other wires in the same section. The voltage generated in them is in the same direction; there cannot be any circulating currents (see Fig. 4).

Cutting Out Coils on Wave-Wound Armatures

After it is determined whether a wave winding is progressive or retrogressive, the pitch of the coil leads is found. (See Fig. 2). To find the lead pitch hold one test wire on top lead No. 2 and run the test wire around the commutator until one bar is found that will make the test lamp light. Then calling the starting bar No. 1, count around to the bar which caused the lamp to light up. In the case of A, Fig. 2, we get in this manner a lead pitch of 1 and 13 or twelve commutator bars. The start was on bar No. 2 and the ending on bar No. 14.

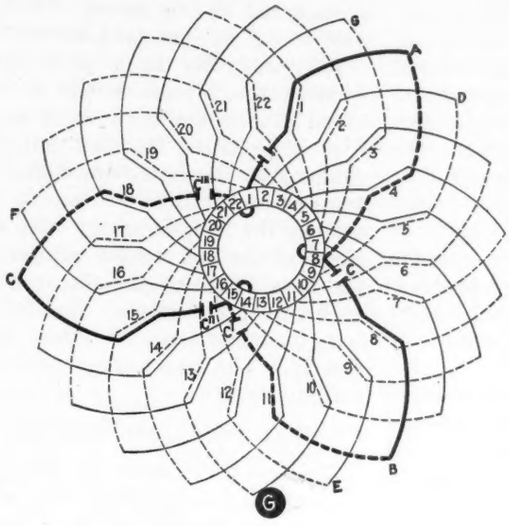
There are formulas for finding the lead for any number of bars but it is always best to test the circuit with a lamp or by other methods. Table I gives the formulas for finding the lead pitch for two-circuit single, series, wave windings, retrogressive or progressive for four, six, eight and ten poles. It will be noted that on a four-pole winding it is possible to have long pitch (progressive) or a short pitch (retrogressive) with the same number of bars. However, on six-, eight-, ten-, and twelve-pole

Fig. 2—Cutting out coils on four- and six-pole windings

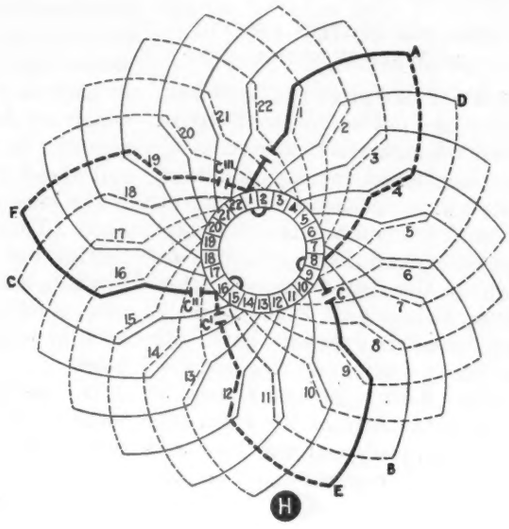


A, B, C and D are four-pole armatures, 25 slots, 25 bars, and coil pitch of 1 and 7. A and B are retrogressive with lead pitch of 1 and 13. C and D are progressive with lead pitch of 1 and 14. E and F are six-pole armatures. Progressive with 20 slots, 20 bars, coil pitch of 1 and 4, lead pitch of 1 and 8. See opposite page for retrogressive six-pole winding.

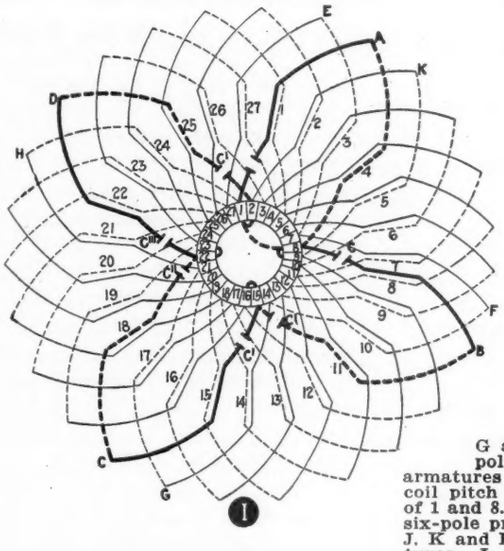
Fig. 3—Cutting out coils on six- and eight-pole windings



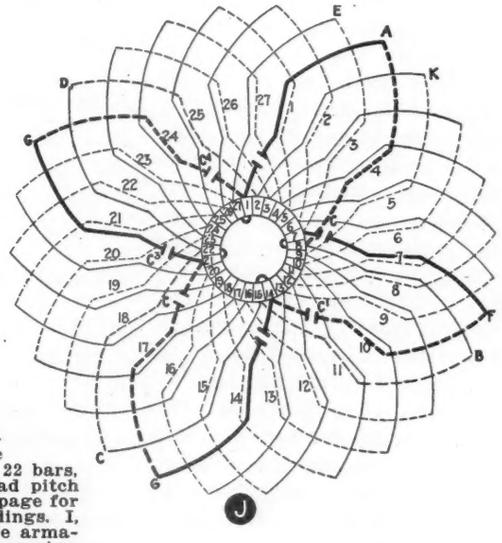
G



H

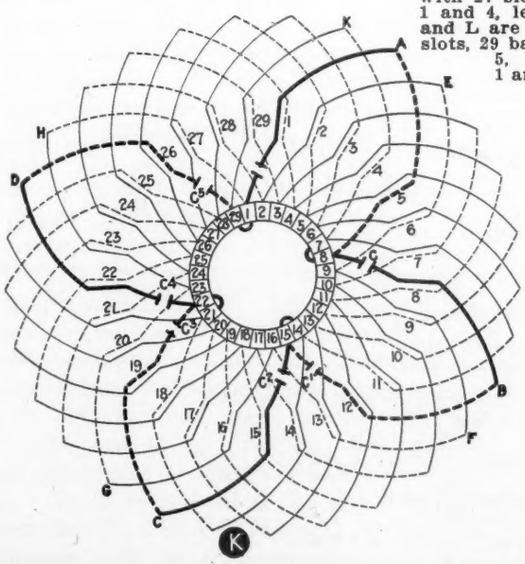


I

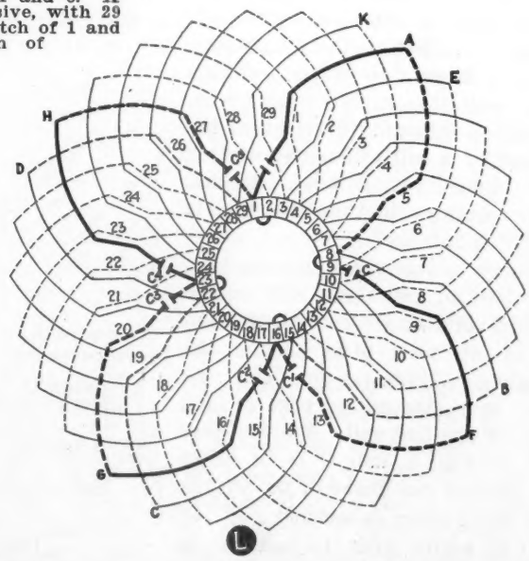


J

G and H are six-pole retrogressive armatures with 22 slots, 22 bars, coil pitch of 1 and 4, lead pitch of 1 and 8. See opposite page for six-pole progressive windings. I, J. K and L are eight-pole armatures. I and J are progressive, with 27 slots, 27 bars, coil pitch 1 and 4, lead pitch 1 and 8. K and L are retrogressive, with 29 slots, 29 bars, coil pitch of 1 and 5, lead pitch of 1 and 8.



K



L

windings only one pitch is possible. The long or short pitch depends upon the total number of bars.

Where the Jumpers Are Put on Wave Windings

After the lead pitch is determined, jumpers are put on to short circuit the coil which is itself opened as already mentioned for lap windings. A long jumper placed across the coil is a quick method but is not always the best. Such long jumpers are shown by the dotted lines in drawings A, E and I of Figs. 2 and 3. These jumpers should have the same cross section as the leads of the coil. Such a jumper should be put on at the rear of the commutator over the leads and well insulated from them to prevent short circuit. It should be held securely in place with a string band. On six-, eight-, ten- or twelve-pole machines this long jumper would save considerable time if only one coil has been damaged. But whenever conditions permit the repairs should be made as shown by the heavy lines from A to L in Figs. 2 and 3. Such methods of connection will make a thorough and more lasting job.

When cutting out coils with the short jumpers, it is necessary to cut out two coils on a four-pole machine, on opposite sides of the armature. Likewise three coils must be cut on a six-pole machine, four on an eight-pole machine, etc. There are two positions for the jumpers on each winding, a retrogressive winding being opposite to a progressive, as shown in the drawings. Both positions are shown for each of the cases given so that the right bars can be jumped and the right coils cut out by following the diagrams.

Before describing these positions it is well to explain the term "ahead" as follows: Starting at the top lead of a coil the center of this coil is "ahead" of the lead. Around the commutator in this direction is said to be "ahead."

In any wave winding, starting with the bad coil there will be one or more coils in series with the bad coil as we pass once around the armature. There is one coil (or more) in series as we pass around *ahead* of the bad coil. For instance in A of Fig. 2, coil D is in series with the bad coil ahead of it. On the other hand there is another coil (or coils) in series with the bad coil as we pass around in the opposite direction or *behind* it. Coil B is in series with the bad coil and behind it.

Using the short jumper the coils in series with and ahead of the bad coil may be cut out. Or the coil in series with the bad coil and behind it may be cut out. It depends on which are damaged or on which mica segment is damaged. Cut out the coil ahead if this coil is damaged or if the mica ahead of the coil is damaged. Thus there are two ways of cutting out coils for a retrogressive winding and two ways for a progressive winding. The diagrams show all four examples for each number of poles.

In general in a retrogressive winding to cut out the coils in series with and behind the bad coil, put jumpers to the bars ahead of the top leads of each coil in this series. Do likewise to cut out the mica ahead. To cut out the coils in series with and ahead of the bad coil, put jumpers to the bars behind the top leads of each coil in this series. Do likewise to cut out the mica behind.

For the coils in a progressive winding the reverse should be followed. To cut out the coils in series with and behind the bad coil, put jumpers to the bars behind the top leads of each coil in this series. To cut out the coils in series with and ahead of the bad coil put jumpers to the bars ahead of the top leads of each coil in the series. The following examples explain this more clearly. The heavy lines show the coils to cut out.

Four-Pole Wave Winding

Take as an example the four-pole two-circuit retrogressive wave winding in the drawing at A of Fig. 2.

Table I.—Lead-Pitch of Single Series (Two-circuit) Wave Windings

No. Poles	Kind of Winding	Lead Pitch
4	Progressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} + 1}{2} + 1\right)$
	Retrogressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} - 1}{2} + 1\right)$
6	Progressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} + 1}{3} + 1\right)$
	Retrogressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} - 1}{3} + 1\right)$
8	Progressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} + 1}{4} + 1\right)$
	Retrogressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} - 1}{4} + 1\right)$
10	Progressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} + 1}{5} + 1\right)$
	Retrogressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} - 1}{5} + 1\right)$
12	Progressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} + 1}{6} + 1\right)$
	Retrogressive	$1 \text{ and } \left(\frac{\text{Total No. of Bars} - 1}{6} + 1\right)$

Example: Take a four-pole armature with 97 bars, then:
For a progressive winding lead pitch =

$$1 \text{ and } \left(\frac{97+1}{2}+1\right) = 1 \text{ and } \left(\frac{98}{2}+1\right) = 1 \text{ and } 50.$$

For a retrogressive winding lead pitch =

$$1 \text{ and } \left(\frac{97-1}{2}+1\right) = 1 \text{ and } \left(\frac{96}{2}+1\right) = 1 \text{ and } 49$$

The coil A has burned open in the top lead between bar 1 and slot 1. Also the mica between bars 1 and 2 and bars 13 and 14 is so badly carbonized that it cannot be cleared without removing the bars and putting in new mica. The commutator, however, is so constructed that the tightening bolts are on the inside and, therefore, not accessible without lifting all the leads and removing the commutator. The best remedy then is to jump the commutator bars between which the mica is bad. Coil D is in good condition. The trouble is in the mica ahead of the bars to which coil A connects. Therefore the coil in series with A and behind it (coil B) is cut open at C and C_1. A jumper is then put across from the bars touching A to the bars just ahead, that is, from bar 1 to bar 2 and from bar 13 to bar 14. Then no leads will be connected to bar 1. The current path will be from bar 2 to coil H to bar 14, through the jumper to bar 13, through coil D to bar 25, coil E to bar 12, etc. The voltage between bars 25 and 1, and between bars 14 and 15 will be a little higher than the voltage between other pairs of bars, because the displacement of coils to which these pairs of bars connect is greater than it is in the rest of the armature.

Taking the same motor in case A, suppose that a short circuit had occurred in coil A which roasted its insulation before the machine could be stopped, and also damaged coil D in series with and ahead of it. The drawing at B of Fig. 2 shows how to cut out both of these coils at the same time. Each bar to which coil A is connected is tied by a jumper to the bar behind it. That is, bar 1 is connected to bar 25 and bar 13 is connected to bar 12. Then cuts C and C_1 are made in coil D as shown. The current path is then from bar 2 to coil H, bar 14, coil B, bar 1 through the jumper to bar 25, thence to coil E and bar 12, etc. It will be noted that bar No. 13 has two open coils connected to it. The question might be asked: Why put on a jumper between it and bar 12? The reason is that if a jumper were not put on, and the brush came in contact with bar 13 an open circuit would result with its attending flashover. The same reasoning also applies to bar No. 1 of A in Fig. 2.

Suppose this is a progressive winding and the trouble is the same as that mentioned for A of Fig. 2. The solution for this is shown in C of Fig. 2. Bars No. 1 and No. 2 are connected together and so are bars 14 and 15. In other words the bars ahead of those connected to the damaged coil are jumped to those connected with the damaged coil. This will cut out coils A and B.

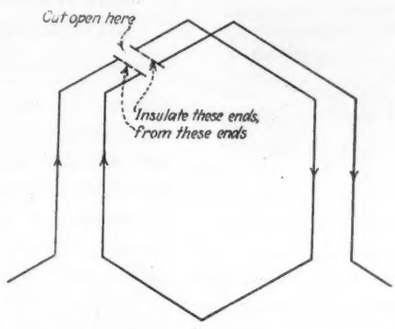


Fig. 4—After coil is cut open, insulate the ends from each other.
The wires lying beside each other may touch, but one group of ends must be insulated from the other group.

In the diagram at D in Fig. 2 the jumper is connected behind the defective coil and coils A and F are cut out.

Six-Pole Wave Winding

At E, Fig. 2, is a progressive six-pole winding. The coil A is cut out, together with the two coils (E and F) in series with A and behind it. The dotted lines between 1 and 8 indicate the manner in which coil 8 might be jumped without cutting out coils E and F.

The same six-pole winding is shown in F of Fig. 2 with the series of coils A, B and C cut out by jumping the commutator bars ahead. In drawing E, the path of the current is from bar 19 to 6 to 13 to 20, through coil K to bar 7 through the jumper H to bar 8 to coil B to bar 15 to coil C to bar 2, etc. In F it passes from bar 20 to coil K to bar 7 to coil E to bar 14 to coil F to bar 1 through the jumper to bar 2, thus jumping out coils A, B and C.

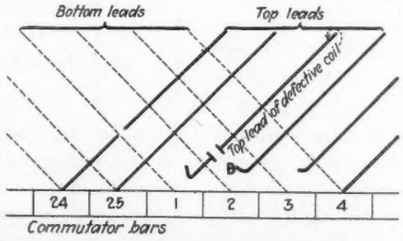


Fig. 5—Finding out whether winding is progressive or retrogressive.
Raise the three top leads, 1, 2 and 3 when 1 is on the defective coil. Hold one test wire on lead 2 and touch the other to leads 1 and 3. For a lap-wound armature if the test lamp lights on bar 1 and not on 3, the winding is progressive. If it lights on 3 and not on 1, the winding is retrogressive. For a wave winding the opposite is true. If the test lamp lights on 3 and not on 1 the winding is progressive. A light on 1 and dark on 3 means a retrogressive winding.

Drawing G in Fig. 3 is a six-pole retrogressive winding with series of coils A, B and C cut out with jumpers placed behind. The current path is from bar 2 to coil D to bar 9 to coil E to bar 16 to coil F to bar 1 through the jumper to bar 22, coil G, bar 7, etc. The same winding is shown in H with the series of coils (F and E) behind A cut out. The jumpers are placed ahead and the path is from bar 2 to coil D, bar 9 through the jumper to bar 8 and coil B and C to bar 22. Coils A, F and E are cut out.

Eight-Pole Wave Winding

An eight-pole progressive winding is shown at I of Fig. 3. The series of coils A, B, C and D are cut out by means of jumpers ahead. The dotted line between bars 1 and 8 indicate how coil A could be jumped without cutting out the coils B, D and C if this was desired. With the short jumper the path is from bar 27 to coil E, bar 7, coil F, bar 14, coil G, bar 21, coil H, bar 1, through jumper to bar 2, coil K, etc. The same eight-pole progressive winding is shown in J of Fig. 3 with the coils in series ahead cut out. The jumpers are placed behind. The path for the current is from bar 27 to coil E, bar 7, through the jumper to bar 8, coils B, C, D to bar 2, etc.

A retrogressive eight-pole wave winding is shown in K. The series of coils A-B-C-D is cut out by means of jumpers behind. The current path is from bar 2 to coil E, bar 9 to coil F, bar 16, coil G, bar 23, coil H, bar 1 through the jumper to bar 29, coil K, etc. The same winding is shown in drawing L of Fig. 3 with the coils in series behind cut out by jumpers ahead. The current passes from bar 2 to coil E, bar 9, through the jumper to bar 8 then through coils B, C and D, to bar 29, etc.

Do Not Cut Out Over Ten Per Cent of Coils

As a general rule when cutting out coils not over 10 per cent of the total number of turns should be taken out of active use. Removing coils from a generator will reduce the voltage in direct (*Continued on page* 408)

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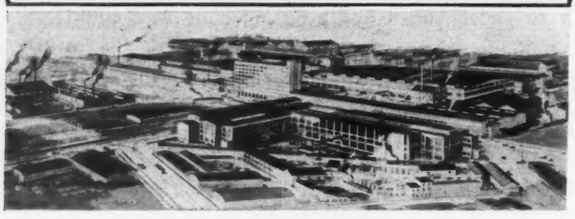


DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, August, 1922

"No Man's Land" Between Motor and Cone Pulley

IMPROVED production methods are subjects of close study these days when elimination of waste or a higher operating efficiency can be realized. Motor manufacturers have made marked strides in reducing electrical and mechanical losses in the motor as a machine and widened its adaptability to all lines of work. Men responsible for production on machines likewise have began at the tool post and by a careful study of the best tools and operations have been able to increase the productivity of the workers frequently by over 100 per cent. This increase in efficiency of the motive equipment and of the machine tool has been made possible because definite responsibilities have been assumed by engineers and production men working toward a specific goal.

But what about that portion of the shop service between the motor pulley and the cone pulleys on the machines? Who is responsible for losses there and who is expected to take the initiative in this "no man's land" between the activities of these other two experts? A line shaft that shrieks and groans as it starts or stops indicates that something is wrong: belts too loose or too tight, hangers out of alignment, poor bearings or any of several other troubles. Each of these unnecessary sounds is a signal of a power loss, perhaps greater than the initial saving through a better drive —a signal, however, which is too often disregarded.

Here is the opportunity for the maintenance man to take his place as an expert on transmission problems. A line shaft that can barely be turned by taking hold of the largest pulley after removing the belts is a waster of power with a loss which continues every minute the shaft is running.

There are opportunities here for the transmission expert to make real savings which will show up in production. Perhaps a larger motor will not be necessary when "it doesn't seem to pull the load any more." Also some maintenance men have found that by going over the line shafts, belts and bearings they have obtained an increase in production of from 5 to 15 per cent and in addition made a saving in power costs. Here is an opportunity for maintenance men who are looking for the chance to do real service and make their work more than a job.

When New Ideas, Like Auto Signs, Say "Sharp Turn"

WHETHER or not we will admit it, most of us are naturally conservative and opposed to anything like radical changes. Our adherence to the old motto "let well enough alone" is often much stronger than the "try anything once" spirit. Conservatism is too valuable a quality to be lightly regarded, but, like many other good things, it may be carried so far that it becomes a liability rather than an asset to its possessor, in that it tends to make him view every innovation with a scornful and skeptical eye. That is fatal to real progress. Granting that an uncontrolled willingness to accept as truth all that one hears or reads may lead to serious errors, it is equally true that an unwillingness to accept, or at least investigate, new ideas will eventually result in one getting out of touch with the latest and best developments.

Despite the fact that modern machinery and appliances are far from being perfect and perhaps never will be, progress toward the ideal is rapid. Equipment and methods which were considered satisfactory ten or fifteen years ago are in many instances hopelessly inadequate as compared with those in use today. There is little doubt that in ten or fifteen years the same thing can be said of the present equipment.

Designers, investigators and inventors, either working alone or in the shops and laboratories of manufacturers, spend millions of dollars every year in the effort to produce better varnish or tape or turbines, and so on. New materials and equipment are constantly being placed on the market, and while it may be the part of wisdom to investigate carefully before adopting them, it is not wise to assume too skeptical an attitude and disregard them altogether.

The snail surrounds himself with a hard shell that effectively protects him from all progress or outside influences, but, in the language of the day, he "never gets anywhere."

Complexities in Ventilation Maintenance

EVEN though a plant is originally laid out according to the best plan, new manufacturing requirements or changes in methods sooner or later demand other changes. It is not uncommon for changes to be made which involve the relocation of entire departments. Additions of machines and alterations of machines are every-day occurrences. And because they are so frequent the maintenance men know how to handle them.

But in the relocation of departments, especially where one or both of the departments involve the operation of a system, the maintenance man finds a new problem. In this line fall ventilating and exhaust systems, for they are seldom if ever replaced in the same relative position in which they were first installed. To make these moves and reinstallations, requires at least a general knowledge of the principles upon which they

operate. For example, he must know the effect of adding to or shortening the duct of an exhaust system and on a plenum system; what would cause a fan to appear overloaded; what might be the trouble if an exhaust system is not giving enough suction; and any of a dozen other troubles which may come up.

Perhaps one of the greatest errors lies in the attempt to get more out of a fan by speeding it up. Air in a fan does not act like water in a pump where increasing the strokes per minute will increase the output and power used correspondingly. To double the output of air from a fan would take eight times the power and would be an overload that could not be put on the driver in most cases. Many of these points are taken up in the article beginning on page 369 in this issue.

Lighting Cannot Be Settled Once for All Time

IN an article on "Light Without Glare" in the August issue of the Journal of the American Institute of Electrical Engineers by Ward Harrison, the well-known specialist in industrial lighting with the National Lamp Works at Cleveland, Ohio, gives some practical comments on the classification of natural and artificial light sources from the standpoint of glare. Reference is made to the data in the revised Code of Lighting of the Illuminating Engineering Society, which has been prepared as a guide for factory owners and operators in improving lighting conditions. In introducing the subject he makes this interesting and very pertinent remark:

> "How many there are who still judge the desirability of a lighting unit simply by its whiteness and dazzling power, criteria which served well in the days when vegetable oil lamps and tallow candles were the only light sources available and when perfect combustion, as evidenced by a brilliant white flame, was a phenomenon altogether too rare. * * * And as to the question of expense in lighting, it may be added that the cost per hour for the 200-candle power lamp is today only about equal to that of the aforementioned candle. * * * Modern developments have made it possible for our great industries to have daylight levels of illumination, and daylight quality of illumination, available throughout the twenty-four hours and ordinarily at the very moderate expenditure of from 1 per cent to 2 per cent of their labor cost. Just what this means, just what the difference is between 1 to 2 foot-candles, the old levels of artificial illumination and 10 to 20 foot-candles, the daylight level of interior lighting, must be seen to be appreciated. One who has tested out for himself his acuity of vision and the difference in his speed of perception under these different levels of illumination has no difficulty in understanding why production invariably falls off with fading daylight in the great majority of our older and inadequately lighted industrial establishments; and how even a night shift in these same plants can be made profitable if proper lighting is supplied."

Adequate lighting, not necessarily flooding a workroom with light, is a subject which every industrial man can study with profit at frequent intervals, particularly if working conditions, the materials or products worked on or the manufacturing processes involved change or vary considerably from time to time. Because lighting conditions are investigated and adequate lighting installed when the plant is new does not by any means settle for all time the best lighting to be used. In this connection the information given by Mr. Harrison will be very helpful.

How Often Do You Test Your Instruments?

A POINT which is frequently overlooked in connection with the use of measuring and testing instruments of practically every kind, is the advisability or even necessity of checking the accuracy of these from time to time. We are forced to rely on our volt- and watt- and ammeters for a great deal of very important data and on the basis of the information which they give, costs and capacities are calculated, installations made and equipment operated.

Present-day instruments are as good as human skill and the knowledge and materials now available can make them. They are, however, necessarily of sensitive construction. Ruggedness must be sacrificed for that lightness and delicacy of the moving elements which is necessary, at least in part, by reason of the small amount of power acting on them. In time a certain amount of wear takes place on the pivots, if not on the jewels; some dust finds its way into the bearings and in various other ways the accuracy and sensitiveness of the instrument are slowly impaired.

In the case of portable instruments this natural wear and tear is supplemented by the unavoidable and often severe shocks incident to transportation from one place to another. It is, therefore, highly advisable to have all such instruments, or in any event those which are used for anything except rough tests, checked up occasionally to make sure that the error in the reading is not excessive. Instruments, like friends, that cannot be trusted are just as bad or worse than none at all.

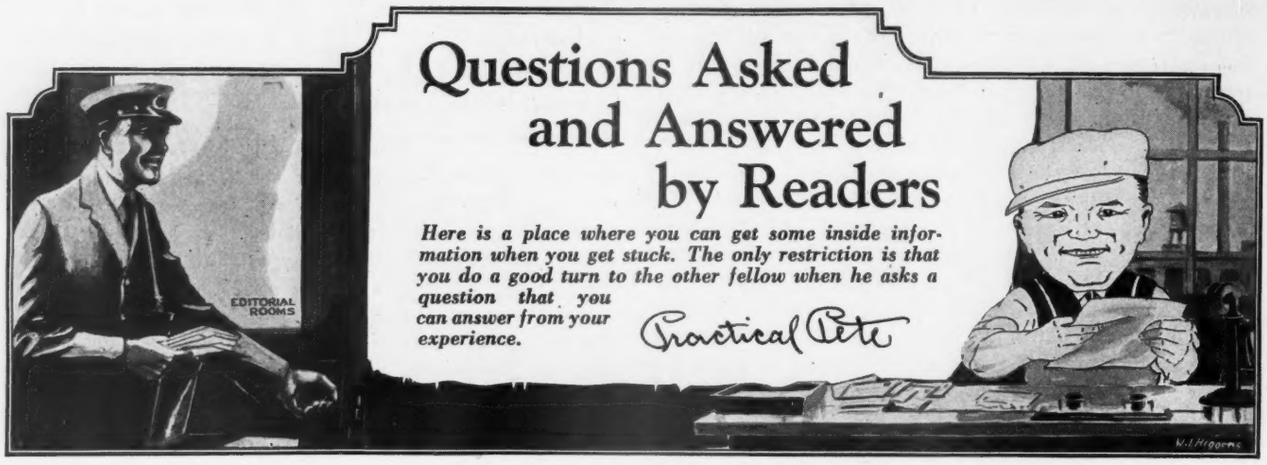
Why Not Do the Outside Work Now?

NOW is a good time to go over the plant and see that all lines and equipment, particularly that which is located out-of-doors, is in good condition. With the coming of Autumn the weather becomes uncertain and is rainy and disagreeable enough of the time to make it worth while to do now as much of the outside inspection and repair work as possible.

Even though no trouble is apparent, it is advisable to inspect with unusual care all of the outside transmission, fire alarm, telephone and other lines to make certain that there are no broken insulators to be replaced, that poles or supports are in proper condition, that the wires are not sagging enough to cause them to be blown together by high winds, and so on. Perhaps fire alarm boxes, transformers, overhead crane tracks or other structural work needs repainting.

Steam, water, air and other lines ought to be examined to determine if repair work is needed in the way of stopping leaks, packing valves, or renewing the coverings. Also, if any new installation work is to be done, either overhead or underground, it can probably be done now more easily and comfortably than later on.

Shortening days mean that more lights will soon be needed and time can be profitably spent in replacing all burned-out or blackened lamps, washing the other lamps and reflectors and doing whatever else is necessary to put the interior lighting system into first-class condition.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Lighting Gas by Electricity.—I would appreciate details of a method by which a 60-cycle, 110-volt, alternating current circuit can be used to light a gas jet instead of using matches. A sketch of a device for this purpose would be helpful.
Wilmington, Del. J. H. G.

* * * *

Why Does Verdigris Form Inside Coils?—In using baking varnishes, we have found that not infrequently verdigris forms on the coils of motors in the slots, and also on the lower windings of magnet coils. (1) Does it impair the insulation? (2) Does it lessen the life of a motor or coil? (3) Can it be avoided by using clear varnishes? (4) Is a good grade of black varnish as likely to form verdigris as clear baking varnish?
Springfield, Mass. J. B. T.

* * * *

Testing Storage Batteries.—I understand that the cadmium test reveals the completion of the charge on a storage battery. Will someone explain just how the cadmium voltmeter test reveals the condition of the positive and negative plates? Kindly outline the various tests for determining the condition of a battery without disassembling it.
Homer, La. A. W. T.

* * * *

Tool Box for Electrician's Equipment.—Several designs of tool boxes are made suitable for tools used by a machinist. I would like to ask fellow electricians to offer for publication in INDUSTRIAL ENGINEER the construction and design for any special tool box which they have found convenient for carrying around the shop the tools that are commonly used and purchased by them personally. I have in mind a small size tool case about 2½ ft. long by 24 in. wide by 24 in. deep with suitable trays and compartments.
Chicago, Ill. J. M. B.

* * * *

Trouble from Grounded Circuit.—Recently we were asked to look over a motor circuit for a school which had grounded all of the radiators in the school house. It was a 3-wire, 110-220-volt line entering the building in conduit with a grounded neutral on a pipe. We cut this ground and rung out the circuit and found no other grounds. As the motor does not run mornings we went away only to be called again in the afternoon. This motor is bolted on two pieces of wood in cement and has been running for four years and never given any trouble until this Spring. All the rest of the wiring was O. K. and we let the job go. There has never been anything done as the janitor gave instructions to keep hands off the radiators. What could be the possible cause of this trouble?
Saranac Lake, N. Y. L. J. R.

* * * *

Number of Conductors in Cables.—I would appreciate knowing a method by which the number of conductors contained in a stranded cable can be found by counting the number of layers of conductors.
New York, N. Y. E. H. B.

Answers Received To Questions Asked

Use of Wire Tables.—In the June number I was interested in the wire tables that were a part of the article on diagrams for winding coils by Mr. Roe, but I do not understand the method of figuring the circular mils from square mils in handling the square wire and ribbon wire. From the formulae I have used the values obtained are greater than those in the tables. I wish someone would explain how to use such formulae in conjunction with the data and tables.
Norwood, Mass. R. E. L.

Perhaps this will answer R. E. L.'s question in the June issue regarding the use of wire tables.

I do not think that square mils can be applied as a measure of ribbon wire since before a correct sectional area can be gained from the product of width and thickness, a reduction factor of about 95 per cent must be finally applied to take care of rounded corners. The tables in question give the actual area in sc are inches corrected for this "rounding" and from which the equivalent area in cir. mils may be obtained by dividing by the number given, .0000007854, which is the area in square inches of one cir. mil. This conversion factor is gained from the knowledge that cir. mils are obtained by first expressing the diameter of a round wire in thousandths of an inch and then squaring same. For example, using a wire .002 in. diameter, or .002 in.=2 mils.

Then the areas are: $3.1416 \times .001 \times .001$ sq. in.=4 cir. mils. Therefore, 1 cir. mil equals $3.1416 \times .001 \times .001 \div 4 = .0000007854$ sq. in.
Cambridge, Miss. C. H. GREEN.

* * * *

Changing 220-volt Motor for Operation on 440 volts.—We have a 10-hp., 220-volt, three-phase, 60-cycle motor which operates at 1,800 r. p. m. It has 72 slots, 36 coils with a throw of 1 to 18. The coils are wound with 12 turns of No. 15 D. C. C. wire. The connection is single-star. In order to operate this motor with a single-star connection on 440 volts at a speed of 1,200 r. p. m. would a winding with coils of 30 turns of No. 17 D. C. C. wire and a throw of 1 to 12 be satisfactory?
Wilmington, Del. I. A.

The proper winding for 1200 r.p.m. 440 volts on above motor would be 36 turns of No. 20 wire with a coil pitch of 1 and 12 and connected series-star. The horsepower of the motor would be 6 2/3. Since there is a voltage and pole charge, the turns required equal $(1800 \times 12 \times 220) \div (1800 \times 440) = 1085$ circ. mils, size of wire equals $(1200 \times 3256 \times 220) \div (1800 \times 440) = 1085$ circ. mils, which equals No. 20. 3256 is the area in circ. mils of No. 15 wire.

The chord factor of the 4-pole coil pitch is .99619 and for the 6-pole winding it is .99144. The difference, .00475, is too small to enter into the calculations.

The horsepower will decrease in direct proportion to the speed, hence the 1200 r.p.m. motor equals $(1200 \times 10) \div 1800 = 6\ 2/3$.

In connection with the wire size to make a cool running motor, try the largest size wire that will fit in the slots with the proper turns; that is, try a slot full of 18 or 19 wire.

Detroit, Mich. A. C. ROE.

* * * *

The following is submitted as an answer to the question on page 296 of the June issue, relative to changing 220-volt motor for operation on 440 volts. The general equation used in making the calculation is:

$E=(4.44\ NTn\times k_1k_2)\div 10^{-8}$ ..... (1)

In applying this equation, use the following values: E_0 equals 220 or original volts; E_1 equals 440 or final volts or voltage desired; N_0 equals 1 or flux per pole of original winding; N_1 equals $2N_0\div 3$ equals 2/3 of flux per pole of final winding; T_0 equals 144 or number of turns in series on original winding; T_1 equals number of turns in series on final winding; n equals 60 or frequency; K'_1 equals 0.946 or chording constant of original winding; K'_2 equals 0.95 or distribution constant of original winding; K''_1 equals 0.92 or chording constant of final winding; K''_2 equals 0.95 or distribution constant of final winding.

Then $E_0=(4.44\times N_0\times T_0\times n\times K'_1\times k'_2)\div 10^{-8}$ ..... (2)

and $E_1=(4.44\times N_1\times T_1\times n\times k''_1\times k''_2)\div 10^{-8}$ ..... (3)

Dividing equation (2) by equation (3) and cancelling like quantities we have:

$E_0\div E_1=(N_0\times T_0\times k'_1)\div(N_1\times T_1\times K''_1)$

Or $T_1=(E_1\times N_0\times T_0\times k'_1)\div(E_0\times N_1\times k''_1)=$

$(440\times 1\times 144\times 0.946)\div(220\times 2/3\times 0.92)=444.2.$

If it is desired to use 36 coils, there will be two coils per pole, per phase and 12 coils in series. The number of turns per coil will be 444.2 divided by 12, or 37 turns. If 72 coils is desired there will be four coils, per pole, per phase, and 24 coils in series using either 18 or 19 turns per coil. Using 18 turns will tend toward a higher power factor.

The proper values of E_0 and E_1 above are 127 and 254 respectively, but since their ratio is the same as the line voltage, the line voltage values were used and the same results obtained. It will be noted that the value of N_0 is taken as unity and N_1 as 2/3 of N_0. This is on the assumption that the flux per unit area of pole face is the same in both the 4-pole and the 6-pole motor. The area of pole face of the 6-pole connection being 2/3 of that for the 4-pole connection.

The equations used do not take into consideration the leakage coefficient. The above calculation is based on coil throw of 1 and 18 and 1 and 12 respectively.

The specifications stated in the problem indicate that one No. 15 wire strand was used on the original winding. This size of wire has 3257 cir. mils nearly. A 10-hp., 220-volt, 1800-r.p.m. motor requires 26.2 amp. at full load. This indicates that the original winding had only 124.2 cir. mils per ampere which is very low. Motors of this size usually have from 400 to 600 cir. mils per ampere. I would assume that each coil was wound of 3 or 4 strands of wire in parallel in which case the 440-volt winding should have the same number of strands as in the 220-volt winding using No. 17 or No. 18 wire, preferably No. 17.

If four strands are used in the 220-volt winding, two strands of No. 15 could be used in the 440-volt winding with a possible slight increase in temperature rise due to decrease in speed.

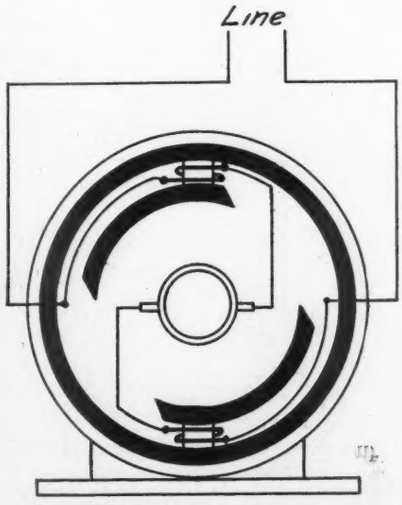
Electrical Engineer. CHAS. R. SUGG.
Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

* * * *

Changing D. C. Motor to Universal Type.—Please give diagrams and other information showing how to change the winding of a d. c. motor to one of the Universal type that will operate on both d. c. and a. c. I refer to a small motor about 1/16 hp. rating.

West Reading, Pa. A. J. G.

A. J. G. who asks in the July issue about changing the windings of a d. c. motor to that of one of the universal type will experience considerable difficulty in making the conversion. Most fractional hp. motors designed for direct current have solid pole pieces. Alternating current passing through the windings of a machine of this type would generate enough eddy currents in the field core to heat the insulation of the motor to the burning point in a very short time. By constructing a laminated field frame (parts of the core of an old 60-cycle transformer may be used) similar to the accompanying diagram the motor will operate at about 70 per cent efficiency on a 60-cycle circuit.



The shaded portions of motor construction should be laminated.

The windings will remain the same if a series motor is used. If of the shunt type for use on a 110-volt circuit, the field coils should be rewound with about 740 turns of number 26 B. & S. gauge enameled copper magnet wire and connected in series with the armature. The speed of the motor while running on alternating current could be varied by shifting the brushes. Care must be taken, however, to avoid excessive sparking.

Chicago, Ill. D. F. O'DONNELL.

* * * *

Wiring for Motors.—In the article by H. L. Cornelison of the March issue on page 129, third column, Mr. Cornelison states that the National Electrical Code permits rubber-covered wire to carry the same current as wire with other insulations providing the circuit feeds only one motor. I cannot find anywhere in the Code where permission is given to wire up to the capacity of Table C. Would you kindly explain how to use Table C and Table A of the Code when wiring for one motor and also when wiring for two or more motors?

Yonkers, N. Y. A. C. B.

In the questions and answers section of the June issue of the INDUSTRIAL ENGINEER, A. C. B. asks where the rule may be found that permits rubber covered wire to be fused to Table C of the National Electrical Code. I would refer him to Rule 8 of the code at the bottom of page 18 and the top of page 19 (1920 edition). There is a misprint here so that where reference is made to Table B it should be Table C. Otherwise than this it seems to me that this rule is very clear and answers A. C. B.'s question.

Everett, Mass. PERCY A. BLAISDELL.

* * * *

The rule in question will be found on pages 18 and 19 of the 1920 edition of the National Electrical Code, rule 8c, second paragraph of division 3, which reads as follows:

"Where rubber-covered wire is used in a branch circuit carrying the current of only one a. c. motor of a

type having large starting current and this circuit is protected by fuses it may be protected in accordance with Table B of No. 18, but in no case should a rubber-covered conductor in a branch circuit carrying the current of only one motor have a carrying capacity in accordance with Table A less than 110 per cent of the nameplate current rating of the motor.

This section has been amended by changing Table B in the fourth line from the top of this column to Table C.

Electrical Engineer, F. D. WEBER.
Oregon Insurance Rating Bureau,
Portland, Ore.

* * * *

Why Should a Factory Keep Its Motor Load Power Factor High?—The motors in our factory have been shifted so that they are not larger than required to do their work. But the power factor is still around 70 per cent. The power company wants to have a condenser installed. I can see how it would help the power company, but I cannot see how it would help us in proportion to the cost of the condenser.

Philadelphia, Pa. H. A. L.

This is a case where there is a question of what is ordinarily good practice becoming a refinement which may not be warranted by results. Since the factory motors are apparently working at 100 per cent load, the factory power factor, with a supply at unity power factor, should be about 85 per cent. Under such conditions the factory is getting full return from its motors without undue heating. But, with the power factor only 70 per cent, the motors are only 0.70÷0.85, or 82.3 per cent efficient. In other words, so far as heating is concerned, the motors are operating at an apparent overload of 17.7 per cent. The question then is, will the motors be harmed sufficiently by this apparent overload to warrant the installation of a condenser in order to save them from it? If they are good motors of modern design, properly rated, it does not seem that the apparent overload would harm them, but if they are 50-deg. motors, the effects of the poor power factor might be quite noticeable.

Honesdale, Pa. J. M. WALSH.

* * * *

If an alternating current generator in the station of the power company is carrying a heavy load at a high temperature but with a low power factor, the product of the machine in kilowatt hours is not a profitable business since the customers pay only for the actual power in kilowatts which their apparatus calls for but not the kilovolts (the product of volts times amperes). The latter includes the wattless current flowing owing to low power factor and heats up the generators just the same as though the load was entirely a power load of high power factor. That is to say, all power energy and no wattless energy. The wattless current load is a burden on the central station company for which they get no pay. If the machines could be relieved of this they could sell the released capacity to other customers.

Steinmetz once said that it is the business of the power company to sell power energy and magnetizing energy (wattless component) and that they should charge for the wattless or magnetizing energy. He humorously compared the situation to the purchase of an alternator by saying that a company when buying an a. c. generator would not expect the manufacturer to throw in the exciter, which is just what the power company now does when selling electrical energy on a kilowatt-hour basis in which no consideration is given to the power factor and the wattless component which is included therein.

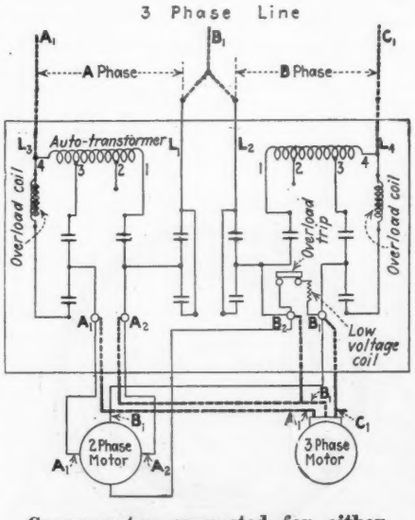
New Britain, Conn. H. S. RICH.

* * * *

Changing Connections of Compensator.—How can a two-phase compensator be changed so that it can be used with a three-phase motor?

Baltimore, Md. R. D.

The accompanying sketch illustrates how a two-phase starter can be connected for two-phase and three-wire or three-phase operation.



Compensator connected for either two or three phases.
Full lines show two-phase four-wire connection. Dotted lines show three-phase or two-phase three-wire connection.

The external connections are the only ones that have to be changed.

Detroit, Mich. A. C. ROE.

* * * *

I am submitting herewith a diagram which I have used successfully for changing a 2-phase compensator to operate upon 3 phases.

Electrical Engineer. CHAS. R. SUGG,
Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

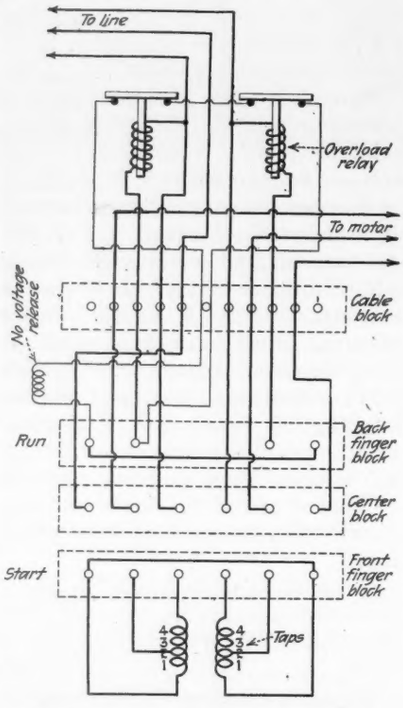


Diagram showing how a two-phase compensator may be used with a three-phase motor.

* * * *

Shifting Brushes of Motor.—In the case of a 3-hp., d. c., shunt-wound, 220-volt motor that operates at 1,700 r.p.m., by shifting the brushes a little against the speed of rotation about 1,720 r.p.m. can be obtained. Will someone please explain why this causes an increase in speed and if the horsepower of the motor is reduced thereby?

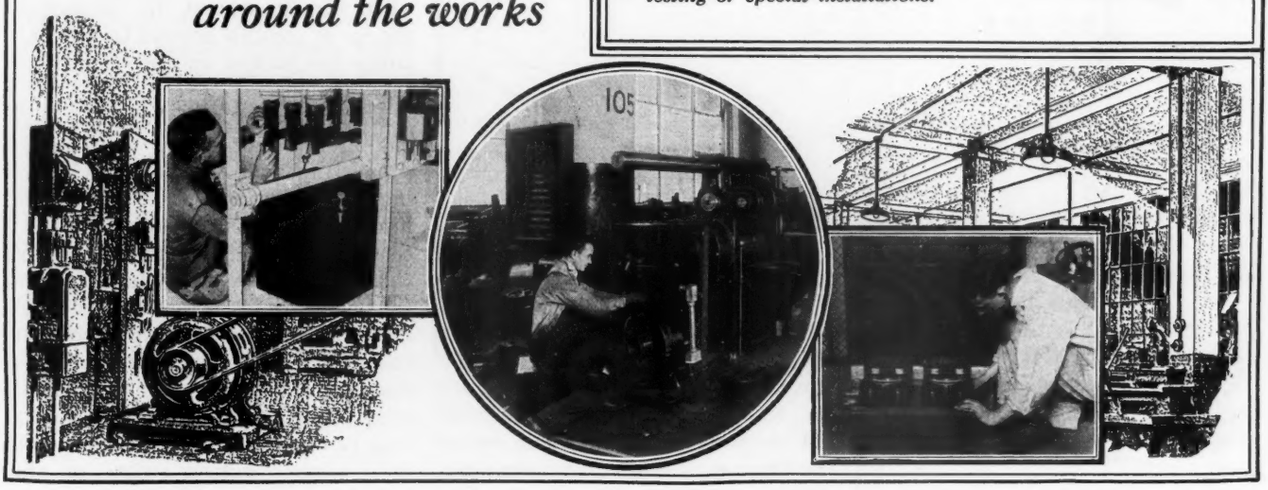
Chicago, Ill. J. A. L.

The speed increases when you shift the brushes back because some of the coils between the poles on the armature are creating an opposing magnetizing force in opposition to the main field, demagnetizing it somewhat. This lowers the counter-electromotive force and thus allows more current to flow into the armature which in turn creates more torque causing the armature to turn faster. A reasonable amount of brush shift does not alter the horsepower to any appreciable extent. It is still of 3 hp. capacity. Shifting brushes will, however, increase sparking especially on heavy loads.

Boston, Mass. EDWARD A. GIBBS.

SERVICE
around the works

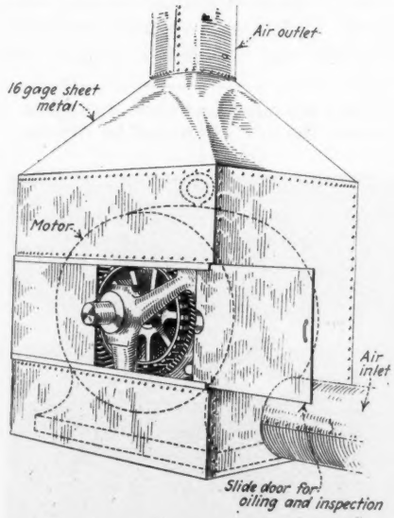
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Metal Housing Which Helps to Protect a Motor From Dust and Gases

IN ORDER to protect a motor from dust, fumes and so on, and at the same time keep down its temperature, the method shown in the illustration has been used by the writer with satisfactory results. As shown, the motor is entirely housed in a metal cover made from No. 16 gage iron or copper, depending on the service. The housing is made in sections provided with hooks and eyes for assembling and can be taken apart in a few minutes. Sliding doors are provided for inspection and oiling. Fresh air is brought from outside the building or from a room where abnormal conditions do not exist, and discharged through the roof or nearest point to the outside. A motor thus equipped will run cooler than one not housed, owing to the free current of air constantly circulating around it.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.,
Port Arthur, Ontario.



The motor is enclosed in a metal housing and air for ventilation is taken from the outside.

Bearing Lubrication Is Dependent Upon Maintenance of Oil Film Between Surfaces

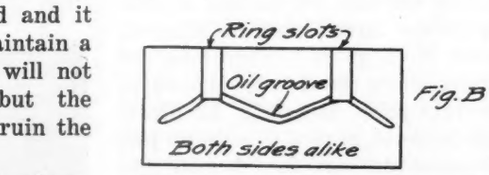
THE lubrication of the ordinary bearing depends upon the maintenance of a film of oil between the shaft and the bearing. In order to maintain this film, proper clearance must be allowed, the amount of clearance depending upon the size of the shaft. If the clearance is too small, the oil film cannot be maintained and the result will be a hot bearing. If the clearance is too great, the shaft will pound and it will be found difficult to maintain a suitable film of oil. This will not only result in heating, but the pounding of the shaft will ruin the bearing in a short time.

One of the largest builders of machinery in the world gives these limits for clearance in small size bearings that are intended for high speeds:

To ½	in. dia.	incl.	0.0005 to 0.001 inch
To 1	in. dia.	incl.	0.001 to 0.002 inch
To 2	in. dia.	incl.	0.002 to 0.003 inch
To 3½	in. dia.	incl.	0.003 to 0.0045 inch
To 6	in. dia.	incl.	0.0045 to 0.0065 inch

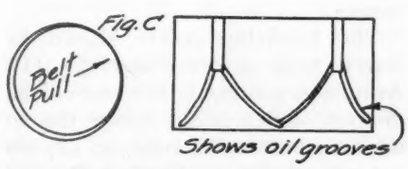
This should be taken to mean that if the shaft is one inch in diameter, the bearing should be bored from 0.001 in. to 0.002 in. larger, and if a shaft is to be fitted to a bearing, the shaft should be turned just that much smaller than the hole.

When the bearing and shaft are perfectly round and the correct amount of clearance has been allowed the shaft or journal is separated from the bearing surface by an oil film. In other words, the journal floats on the lubricant. Grooves are cut in the bearings at right angles to the direction of motion to aid in spreading the oil film over the bearing. However, if the

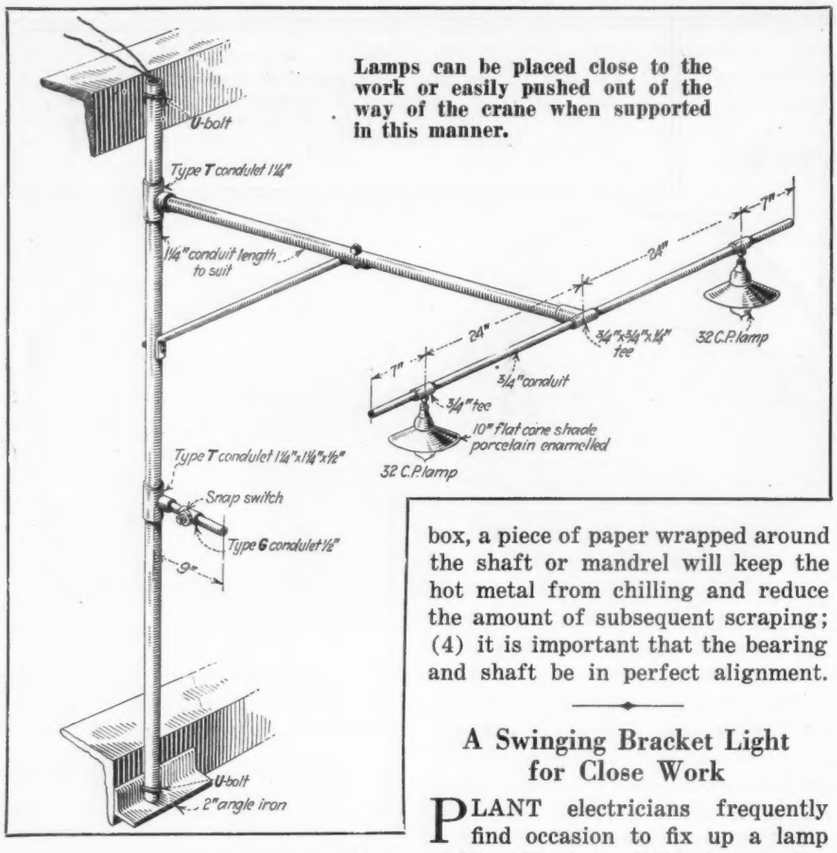


Pressure of the shaft on the bearing on motor-generator set.

Oil groove for bearings with no side pull.



A spiral oil groove for a bearing with a belt pull.



Lamps can be placed close to the work or easily pushed out of the way of the crane when supported in this manner.

side of the box is too much cut up by oil grooves the bearing space will be too small and the oil film, which is under pressure sometimes as high as 200 pounds per square inch, cannot be maintained. Generally speaking, there should be no oil grooves on the side of the box toward which the shaft is drawn by the belt or other working load. The rotating shaft will then pick up the oil from these grooves and carry it over to the side under pressure.

In motor-generator and other bearings having no belt pull, the shaft, when standing still, rests on the lowest portion of the bearing, but when the shaft starts running it rolls up the side of the box a little way in the direction of rotation, as shown in Fig. *A*. Therefore, oil grooves along the side provide oil at the right point, as in Fig. *B*. Bearings liable to have a side or up pull are more difficult to lubricate; so spiral grooves with heavy slant, Fig. *C*, have been found to give the best results.

The following points should be kept in mind in fitting bearings: (1) Avoid sharp edges or corners on the grooves, which might scrape the oil off the shaft as it rotates; (2) do not cut oil grooves through the end of a box, as this will allow the oil to run out; (3) when babbitting a box, a piece of paper wrapped around the shaft or mandrel will keep the hot metal from chilling and reduce the amount of subsequent scraping; (4) it is important that the bearing and shaft be in perfect alignment.

A Swinging Bracket Light for Close Work

PLANT electricians frequently find occasion to fix up a lamp which will give a light close to the work, as is necessary in inspection, lathe work and close bench work, but which can be swung out of the way to permit a crane to pass or to lift work in or out of a machine. One method of doing this is by attaching a swinging lamp bracket to a side wall or column as shown in the accompanying illustration. This is easily made from conduit and standard fittings. The bracket shown is used on a lathe for turning rolls in a steel mill, where it is better to use several lamps of low candlepower comparatively close to the work, and so get soft light with a minimum of glare on the polished surface of the rolls, than to have a stronger lamp placed higher. For this reason, 32-cp. lamps are used with 10-in. flat-cone shade, porcelain-enameled reflectors. The reflectors are protected from coming in contact with the wall, when swung around, by extending the ¾-in. conduit beyond them. The lamps are turned on and off with a snap switch.

A similar arrangement can be used out on the floor where there is no supporting wall or column by making a supporting socket of a pipe nipple large enough for the 1¼-in. conduit to fit inside and screwing this into a floor flange attached to the floor with lag screws. If convenient, fastening the upright conduit to a machine or bench two or three feet from the floor would make it more substantial. Also the lights may be controlled by dropping a cord with a push button switch on the end from the cross conduit so that it will hang within convenient reach.

The exercise of a little ingenuity will indicate how other similar fixtures for lighting units can be designed and made to meet special needs or conditions. The cost, both in time and material, is usually negligible, inasmuch as they can be made from odds and ends obtainable in any repair shop, and is certainly far outweighed by the many advantages accruing from adequate illumination of the work.

Cambridge, Ohio. R. S. LOWRY.

Safety Switches Stop Joy Riding on Industrial Trucks

IN ORDER to keep unauthorized persons from riding on the industrial trucks in a Pennsylvania plant, safety switches have been mounted on them and connected so that the

When the safety switches are locked open, the trucks cannot be driven.

control circuit can be locked open. The accompanying photograph shows two methods of mounting these switches. Before this precaution was taken persons other than the operators would often drive the trucks. The regular operators would also do a good deal of running around on them after working hours. The safety switches, however, are locked open at the close of each day or whenever the operator leaves a truck. This has prevented damage from accidents, injury to the control parts caused by inexperienced persons operating the trucks, and waste of energy from the storage batteries.

Swissvale, Pa. F. W. McGRAW.

Ball Thrust Bearing Reduces Power Consumption of Motor Driving a Pump

BY INSTALLING a ball thrust bearing on a motor driving a single stage pump in this plant, the power consumption was reduced 13 per cent. The motor was a 75-hp., 1,200-r.p.m., three-phase induction motor, direct-connected to a 12-in. single-stage pump operating a bleaching engine in a sulphite mill. With single-stage pumps there is always more or less end thrust, which pulls the rotor out of alignment, causing extra friction on both pump and motor bearings, and consequently adding to the motor's load. The motor in question operated at 20 per cent overload constantly when equipped with the ordinary sleeve bearing. In order to remedy this condition a ball thrust bearing was installed on the coupling end of the pump. This reduced the power required from 90-hp. to 78-hp., giving a saving of 12-hp. Fig. 1 shows the type of bearing used, while Fig. 2 shows the loads before and after the change. Before the change the power fluctuated considerably more than afterward.

Fig. 1—When this thrust bearing was installed between the pump and motor the power was cut from 90-hp. to 78-hp.

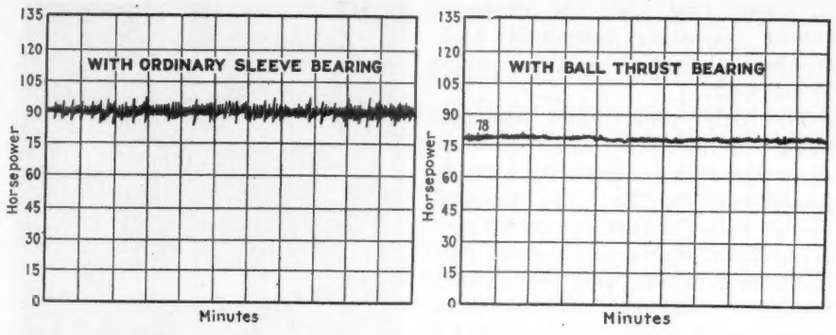


Fig. 2—Load curves of motor before and after putting in ball-type thrust bearing.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.,
Port Arthur, Canada.

Lead-Covered Wire Most Satisfactory for Use in Wet, Salty Atmosphere

THE conditions of service which the wiring in packing houses must withstand are peculiar in several respects. The usual methods for the wiring of buildings, therefore, require considerable modification in accordance with principles which are not new, but which are seldom encountered in interior work.

The outstanding feature of the conditions is the extreme dampness of the atmosphere within the plant. This is most serious in the cooling rooms where warm, freshly dressed carcasses are stored. These rooms are cooled by having cold, moist air (as near 100 per cent humidity as possible) forced in by blowers. The air is cooled and humidified by being blown through a spray of salt water which has itself been cooled to a low temperature by running over radiators containing ammonia. Salt in the water is necessary to keep it from freezing. Moist air is necessary to retain the red color of the meat; dry air would cause it to darken and would, moreover, cause a loss in weight due to evaporation.

The electrical conduits extending into these rooms enter them from regions where the air is necessarily much warmer and usually moist, as is almost everywhere the case in packing houses. The result is that a great deal of moisture is continually being condensed in these conduits, keeping them wet almost all the time. Salt from the air of the cooling rooms also collects in the conduits. This moisture with the salt in solution spreads widely through the conduit system wherever the pipes are in continuous connection. This is evidenced by the fact that when wire is pulled out from conduits having such continuous connection with conduits passing through cooling rooms, large amounts of salt water come out with it.

Moreover, the excessive amount of moisture almost everywhere present in the atmosphere of packing houses, leads to a good deal of condensation in the conduits throughout the entire plant, as they, of necessity, pass through warm and cool places.

Wire with braided covering consequently deteriorates very rapidly,

no matter how high the grade of rubber insulating compound used, frequently becoming unfit for service in one year.

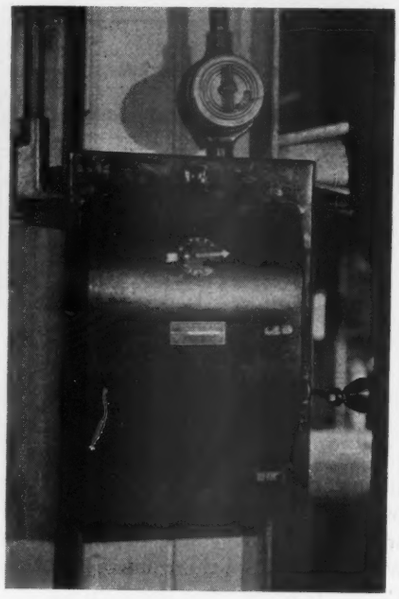
The only proper and adequate method of meeting these conditions is to use rubber insulated wire as specified by the "National Electrical Code," with the outside braided covering replaced by a lead sheath. This has been done with very satisfactory results in several specific cases known to the writer; in these instances lead covered wire has been in service for several years without showing any sign of deterioration. This is really standard practice for moist locations, according to the Code. For example, all wire or cable which is installed in underground systems must be lead covered on account of the moisture always present in such places. The Marine Code of the American Institute of Electrical Engineers also specifies that on ships all wires below the water tight deck, as well as in other moist places, should have a covering of lead on account of the condensation which takes place on the ironwork below the water line. The fact that rubber and braid, even if impregnated, will rapidly deteriorate in moist locations is so well known to engineers that it is remarkable that wire of that kind is still occasionally found in such places.

In addition to trouble from wet conduits, serious deterioration of braided wires is experienced in the rooms where fertilizer is made from refuse material, on account of the presence of ammonia and other chemicals; it is also experienced in the pens where live animals are kept before slaughtering, on account of the ammonia in the manure. Lead-covered wire has been found to stand up well in these locations.

The conditions in the places where the blowers and spray apparatus mentioned above are located are so severe, on account of the salt spray, that lead-covered wire is a necessity.

Two-conductor lead-covered wire costs about twice as much as two-conductor braided wire, but the life of the latter is so short, the maintenance so high and interruptions of service so frequent, that lead-covered conductors are more economical.

Field Engineer, Habirshaw Electric Cable Co., New York City. F. A. WESTBROOK.



The safety switch opens the circuit after which the snap switch reverses two of the three phases of the motor.

A Simple Method for Reversing the Rotation of a Motor-Driven Machine

WHEN a motor does not have to be started under load, the switch arrangement for reversing it, illustrated in the accompanying cut, is satisfactory and economical. This consists in a safety switch which is used for starting and stopping the motor and a double-throw snap switch which is used for reversing the direction of current after the circuit has been broken by the safety switch. The snap switch is a 20-amp. indicating switch and is mounted on a condulet above the safety switch. It is connected into two of the three phases of the 3-hp. motor driving a profile machine which may be operated both right and left. When it is desired to change the direction of operation, the 30-amp. safety switch is opened and the snap switch is reversed.

Swissvale, Pa. F. W. MCGRAW.

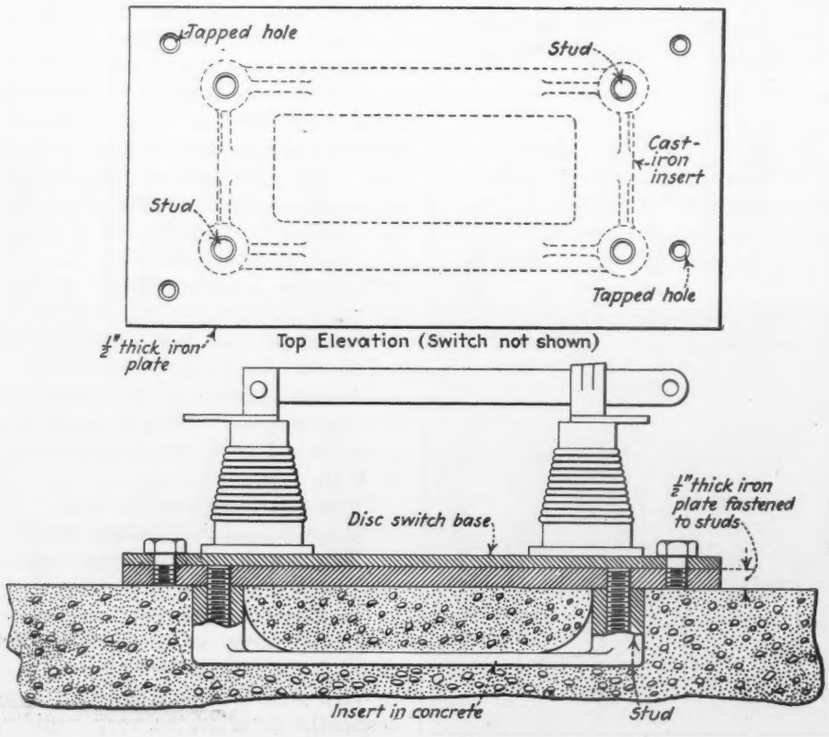
Using a Standard Cast-Iron Insert for Mounting Any Size of Switch

IT HAPPENED recently that when a switch was to be mounted on an insert in a concrete wall the switch base was too large for the insert which had been installed. The construction man on the job overcame the difficulty by the simple method shown in the accompanying drawing.

A ½-in. thick iron plate was fastened to the insert with four studs. The base of the switch was then mounted on this plate by means of holes which had been drilled and tapped in the plate at the proper points. Current transformers and other equipment can be fastened to concrete walls by this method.

New York, N. Y. FRANK HARAZIM.

Because this switch base did not fit the insert, the switch was mounted on the ½-in. plate which was fastened in turn to the insert.



Annunciator System Saves Delay at Jig Room Window in Machine Shop

IN A large lathe-and-drill machine shop of an industrial plant much delay was experienced by the operators in getting the proper jigs and drills at the jig-room. Oftentimes seven or eight well-paid men had to wait at the window while a search was being made for something that could not readily be found.

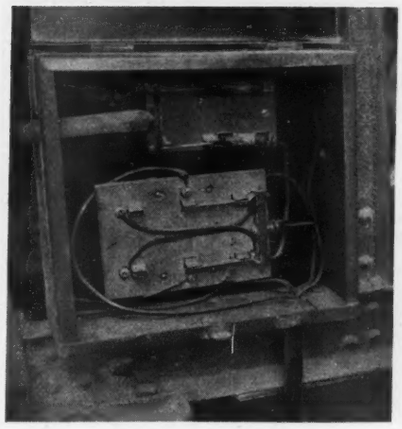
The use of an annunciator was suggested and it was installed in the jig-room while push buttons were distributed around the room within reach of the various machine operators. A call is answered by a shop boy who ascertains the operator's needs, gets the article from the jig room by depositing a check and immediately delivers it. The messenger is not permitted to be delayed or employed by any operator and when he is otherwise not engaged he grinds tools in the jig room.

H. S. RICH.

East Berlin, Conn.

Two Attachments Which Simplify Motor Control on a Portable Machine

A PORTABLE bag piler used at the Chicago warehouse of Lange, Merrill and Sommers is driven by a small 220-volt a.c. motor which is reversed for taking bags from the pile by a double-throw knife switch, as shown in the accompanying illustration. As this switch was also used for starting and stopping the motor, to operate the switch, which is placed near the floor on the machine, necessitated opening the switchbox and reaching down into it. Unless the operator stooped down low, he ran the risk of getting in contact with the blades or other live parts. To overcome this difficulty, the electrician cut in a single-throw, double-pole, 50-amp., 220-volt Westinghouse switch and fuses in the line just ahead of the double-throw switch. He also cut a hole in the side of the switchbox and placed an extra long handle on the single-throw switch so that it projects about 1½ in. through the side of the box. Now the motor is started or stopped by throwing the single-throw switch in or out while the double-throw switch is kept in, thus avoiding opening the switch box except on the rare occasions when it is necessary to reverse the motor.



How a switch box was made safe. By adding a single-throw switch with a long handle extending through the side of the switchbox the operator starts and stops the motor without opening the box except when it is necessary to reverse the motor.

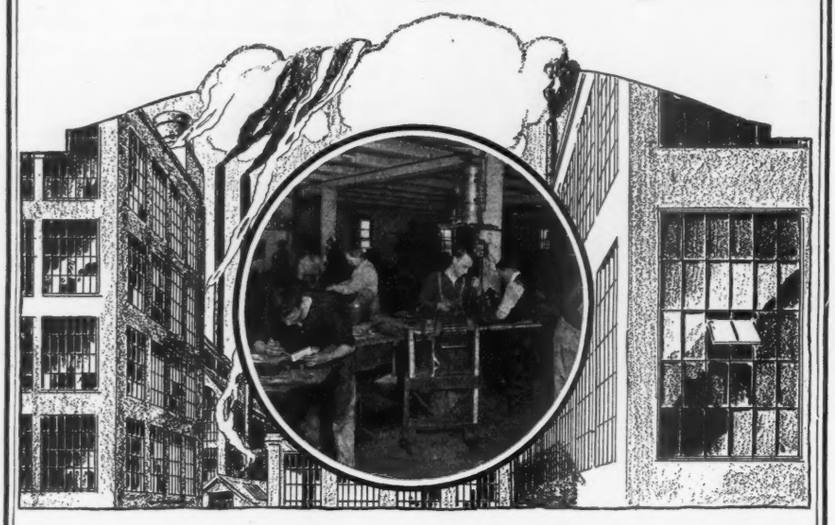
At the same time this switch was put in the 100-ft. extension cable which came attached to the machine was cut off and a push socket added to the top of the switch box and a push plug attached to the end of the cable so that the latter can be disconnected from the bag piler. This makes it easier to move the piler. Also the cable is wound up on a home-made reel when not in use which keeps it out of the way and less liable to damage by being run over by trucks, getting tangled, or tripping the men.

Pipe Support Gives Convenient Adaptation of Motor Drive for Screw Machine

THE adaptability of individual motor drive for machine tools is well illustrated by the conversion of a group-driven installation in an East Springfield, Mass., factory. A variety of motor mountings were necessary in fitting up this plant for its conversion from the group-drive installation, which had been used for producing rifles for war service, to individual motor drives. The accompanying photograph shows how a Garvin No. 2 hand-screw machine, belt-driven, was connected to a 1-hp., 440-volt induction motor. The motor is mounted directly on a heavy wooden base bolted to a pipe flange at the top of the 3-in. supporting pipe which is set in the floor. The starting switch is attached to the wooden base by ¼-in. by 1-in. iron straps. The arrangement carries both motor and starting switch above the machine and behind it, keeping the switch, however, within easy reach of the operator at his post in front of the machine. The motor is high enough to give a belt long enough for smooth running.

A 3-in. pipe support gives a substantial individual-motor mounting for driving this hand-screw machine.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Welding Squirrel-Cage Rotors With the Electric Arc

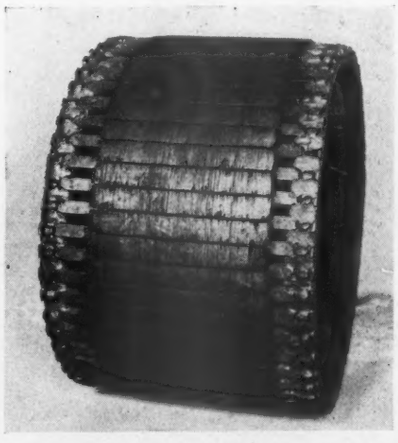
THE rotors of squirrel-cage induction motors are often constructed by tapping the end rings and attaching them to the cross bars with cap screws held in position by lock nuts under the heads of the screws.

Another type of rotor construction uses ordinary machine bolts with the nut locked in position on the inside of the ring by a lock washer. Under the severe conditions of service, however, the bolts frequently work loose in spite of the lock washers. In making repairs, arc welding may be used successfully to weld the cross bars permanently to the end ring.

The cross bars are high-grade copper, whereas the end rings are usually an alloy of copper designed to produce the proper amount of resistance in the squirrel-cage winding so as to give the motor the proper starting and operating torque characteristics. To weld these cross bars, therefore, to the end rings requires different materials and different manipulation from that ordinarily used in arc welding steel plates or castings.

The accompanying illustration shows how the 55 cross bars of a squirrel-cage induction motor rotor were welded to the end rings. The steel bolts were left to hold the bars in position when welding and also as an additional safeguard.

When welding this rotor the operator used the graphite electrode process and a filler material of phosphor-copper containing approximately 8 per cent phosphorous. With a current of approximately 100 amp., about one minute is required to weld the first two or three bars. By that time the adjacent cross bars and the end ring near the welding operation have been heated up so that subsequent bars can be united with the end ring in about 30 seconds. The entire 110 welds on this rotor were made in about 1½ hours. It is necessary to use the phosphor-copper material as specified in order to get the proper fluidity of the molten filler material so that it will unite properly with both of the pieces to be welded together.



The copper cross bars were arc welded to the copper-alloy end rings of this small induction motor rotor in approximately 1½ hours.

A. M. CANDY.
Arc Welding Engineer,
Westinghouse Electric and Manufacturing Co.,
East Pittsburgh, Pa.

Reducing the Time Required for Baking Out an Armature

A PLAN for quickly baking out an armature has been used by the writer with great success. In this method the armature is heated by passing current through the armature in addition to gas and electric heaters.

Recently the shop received a 35-hp. direct-current armature that had been submerged in water and showed a full 220-volt ground. The armature was placed in a small oven with a gas stove and an electric stove, one at each end. Taps were taken at four points on the commutator and these were connected to the secondary of an old wireless 3-kw. transformer. The secondary was made by wrapping about twenty turns of heavy line around the 110-volt winding of the transformer. In less than one-half an hour the armature was warm all over from the heat of the winding.

After baking the armature this way for about eighteen hours, the ground disappeared. A similar job done some time ago with an ordinary gas stove baking took thirty-six hours.

GEORGE BENDER.
New York, N. Y.

Reconnecting a Motor to Reduce Speed from 1200 r.p.m. to 900 r.p.m.

IN THE plant with which the writer is connected a 900 r.p.m. 35-hp., 550-volt motor was needed recently, but none was available. There was, however, an idle 50-hp., 1,200-r.p.m. induction motor, which had been damaged by one of the fan blades breaking off. As this motor had to be rewound and was not really needed as a spare, it was decided to use it for the desired application, provided it was suitable.

This motor was of the open-slot type with form-wound coils and had 96 slots and coils. Estimating the winding gave the following data: Connections—adjacent-pole, series-star; number of slots—96; number of phases—3; frequency—60 cycles; synchronous speed—1,200 r.p.m.;

Values of Output Coefficient K

Output is expressed in horse-power, linear dimensions in inches, and speed in rev. per min.

Pole Pitch, In.	4 Pole	8 Pole	12 Pole	16 Pole	20 Pole	24 Pole
	Numbers in each column should be multiplied by 10^{-5}					
5	.....	2.5	2.65	2.63	2.54	2.46
7	2.22	3.29	3.31	3.31	3.31	3.31
10	3.36	3.9	3.94	3.94	3.94	3.94
12	3.92	4.36	4.38	4.40	4.43	4.43
16	4.34	4.82	4.84	4.86	.....	.....
20	4.54	5.05	.....	.....	.....	.....

full-load speed—1,160 r.p.m.; number of poles—(60×60×2)÷1,200=6; full pitch—96/6=16 (100 per cent chord factor); number of coils per pole-phase group—96÷(3×6)=5 1/3 or 6 groups of 6 coils each equals 36, and 12 groups of 5 coils each equals 60 and 6+12=18 groups and 36+60=96 coils. The motor, however, was not wound full pitch, but 7/8 full pitch, or 7/8×16=14, the coil sides being in slots 1 and 15.

Since the motor having the least number of poles requires the greatest depth of laminations below the slots, reducing the speed did not affect the area traversed by the flux.

The redesign brought out the following figures: Number of slots—96; number of phases—3; frequency—60 cycles; synchronous speed—900 r.p.m.; number of poles—(60×60×2)÷900=8; full pitch—96÷8=12 (100 per cent chord factor), and number of coils per pole-phase-group—96÷(3×8)=4.

It was decided to use the same size coil as before and wind full pitch, as this would slightly decrease the output and at the same time help the power factor of the motor. Also the motor could at any time be reconnected for 6 poles with a chord factor of 93 per cent at 3/4 full pitch. Since 96÷6=16, and 180 degrees÷16=11 1/4 electrical degrees for each slot, 3/4 full pitch= 16×3/4=12; the electrical degrees per pole equal 11 1/4×12=135 degrees. Since the chord factor is the sin of one-half the angle, chord factor=sin 135÷2=0.93.

The approximate output in horsepower at the new speed was figured by the formula: Hp.=K×D²×L×r.p.m., where hp.=output of motor, K=output coefficient depending on pole pitch and number of poles, from the accompanying table, taken from "Design of Polyphase Motors and Generators," by Hobart; D=inside diameter of stator; L=length of stator teeth radial to the shaft; r.p.m.=speed.

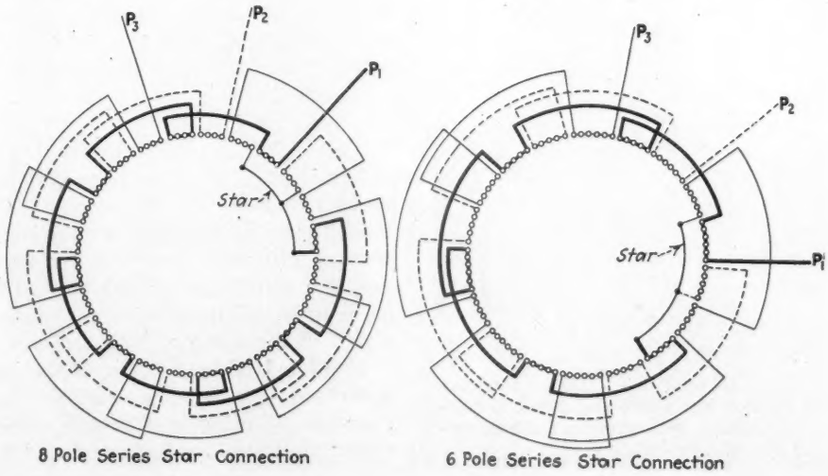
For this stator, D=14 1/2 inches. The pole pitch in inches was found from the formula: Pitch=(diameter×3.14)÷number of poles, or (14.5×3.14)÷8=5.7 The output coefficient K at this pitch and number of poles=0.000025. The approximate output then=0.000025×(14.5)²×8×900=37.8 hp. This was near enough, as the motor previously used on this application had an output of approximately 35 hp.

Before putting the motor into service, tests gave the following results: Starting current at no load, 95 per cent of previous starting current; no-load current 1 per cent higher than a standard 35-hp. motor; no-load speed 895 r.p.m.

The motor has been in service for some time under severe conditions, carrying an almost constant load of 35 amp. and intermittent loads as high as 45 amp. with no increase over normal full-load operating temperature. The accompanying diagrams at the bottom of the page illustrate the grouping and connections before and after the change.

H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont.

Induction motor connected for 1,200 r.p.m. (left) and for 900 r.p.m. (right).



8 Pole Series Star Connection

6 Pole Series Star Connection

Changing the Voltage of a Direct-Current Motor

IN CHANGING a 110-volt shunt-wound motor to operate on circuits of 220 volts, the repair man found it necessary to rewind the six field coils with twice the number of turns and one-half the size of wire which were previously used. The change in the armature, although it did not require rewinding of the coils, was a trifle more complicated. The process was as follows:

The 110-volt armature had 100 slots, 100 commutator bars and 100 one-turn open-end coils, consisting of two 1/2-in. by 1/16-in. copper conductors in parallel. The pitch of the coil on the armature was 1-17 and the throw of the leads on the commutator from bar 1 to 34. It can be seen in Fig. 1*a* that the 110-volt winding is a single series of wave, single re-entrant, retrogressive winding, with two paths or circuits of fifty coils per path.

The first thought in changing from 110 volts to 220 would be to double the voltage, double the number of armature conductors or turns in series per path and decrease the area of copper per conductor one-half. As the original coil consisted of one turn of 1/2-in. by 1/8-in. copper wound on edge, to make a two-turn coil, using the same commutator, would mean making a coil out of

¼-in. by ⅛-in. copper strap wound on edge. This would not be an easy coil to make and insulate. Discarding the two-turn coil idea and investigating the 110-volt armature winding showed that the individual straps or coils (*A* and *B*, Fig. 1*a*) were insulated from each other, forming practically 200 single coils of ½-in. by ⅛-in. copper (being connected two in parallel to the commutator as shown in Fig. 1*a*), and that the insulation was in first-class condition. In fact, it stood standard test voltage to ground and between straps *A* and *B* in Fig. 1*a*, the last test being made after the commutator was removed and the ends separated.

Having 200 good coils on the armature, which is the required amount for 220 volts, the problem then became a question of whether a 200-bar commutator and 200 coils could be connected into a single-series retrogressive winding. If this could be done, a commutator having the required number of bars could be substituted without disturbing the armature coils.

Applying the single-series armature winding formula to the 200-bar winding there resulted: $B=(P/2)\times T+1$, where B=number of bars and coils, P=number of poles, T=throw or pitch of lead on commutator. Then, for this winding, B=200 and P=6, so that $200=(6/2)\times T+1$. Therefore $T=(200/3)=66+2$. This would make the pitch of leads 1 and 67, which would form a double-series retrogressive winding of four paths of fifty coils per path. As this is the same as the original winding, it would only develop 110 volts. It is visually shown in Fig. 1 why 200 bars cannot be wound single-series retrogressive, the diagram being reduced to one-tenth scale, i. e., twenty bars and slots. Using the formula in this case, T will be 6 and the throw will be 1 and 7. The remainder of 2 means a series of $P/2$, or three coils would encircle the commutator and end two bars behind the starting point. Starting at bar 1 (Fig. 1), through coil in slot 1 and 4 to bar 7—13 brings the coil end at bar 19, whereas a single-series winding should end up one bar ahead or behind the starting point, one bar ahead for a progressive or one bar behind for a retrogressive winding. Upon further investigation, the winding will be found to continue from bar 19 to 5-11-17-3-9-15 to bar 1, the starting point, passing through ten coils before closing on itself.

The diagram also shows that there is another series of ten coils interplaced between the series shown in the medium black lines, or starting at bar 2, then to 8-14-20-6-12-18-4-10-16 and then back to bar 2, the two windings being entirely separated and consisting of ten coils each. Then if brushes be placed as at *A* and *B*, brush *A* will be in contact with bars 20 and 1, and brush *B* with 10 and 11, so that the winding will be divided into four parallel paths of five coils per path (fifty coils per path for the 200-bar winding). The paths are from brush *A* bars

1-7-13-19-5-11

10-6-12-18-4-10

these coils being followed around the armature in a clockwise direction to brush *B*. The other two paths starting at brush *A*, bars 1 and 20, are followed through counter-clockwise, i. e., from bars

1-15-9-3-17-11

20-14-8-2-16-10

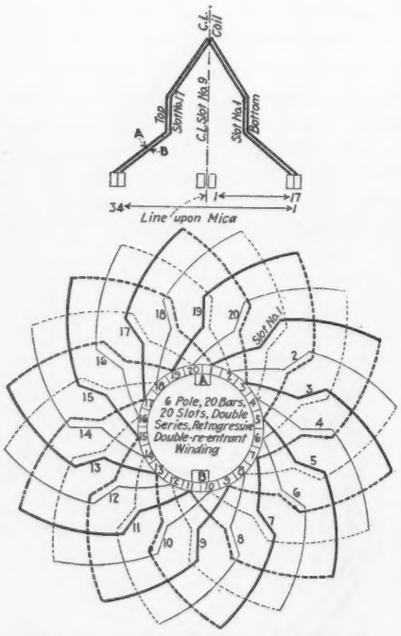
to brush *B*. From the above, it is obvious that even if there were 200 coils in the armature it would still develop 110 volts, there being two separate windings of 100 coils, or four paths of fifty coils per path, which is the same as originally.

Two hundred bars and coils can be connected into a single-series progressive winding by making the throw of leads 1 and 68, or 1 and 8, since (Fig. 1) this would permit a series of three coils to end up one bar ahead of the starting point. As the original winding was retrogressive, to change it to progressive would reverse the direction of rotation of the armature.

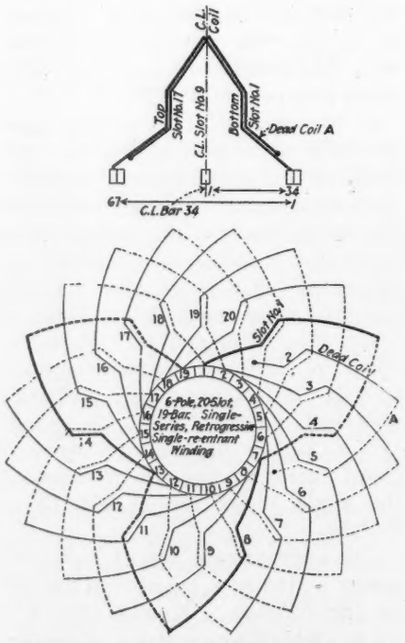
Trying the formula, to find the number of bars nearest to 200 that can be wound single-series retrogressive, we have $B=(P/2)\times T+1$, or $3\times 66+1=199$ bars. This arrangement will give the proper throw of leads on the commutator, being 1 to 67, and form a single-series retrogressive winding of two paths of 100 coils per path, which is required for 220 volts. Fig. 2*a* shows the 220-volt winding data as given to the armature winder, and Fig. 2*b* shows the 220-volt winding reduced one-tenth, i. e., nineteen bars and nineteen coils, one coil being dead-ended as shown at *A*. Investigating Fig. 2, it will be seen that a series of three coils starting at bar 1 and going to bars 7-13-19 will end one bar behind the starting point, and that the winding continues on to bars 6-12-18-5-11-17-4-10-16-3-9-15-2-8-14, then back to bar 1, passing through all the nineteen coils.

A 199-bar commutator was then pressed into place, and the winding connected as per Fig. 2*a*, one coil being dead-ended as at *A*, in that illustration. It has been running satisfactorily since.

New York City. C. A. JOHNSON.



Figs. 1a and 1b—Winding data for 110-volt armature and 110-volt double series retrogressive, single re-entrant winding.



Figs. 2a and 2b—Winding data for 220-volt armature and 220-volt single-series retrogressive single re-entrant winding.

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Handling 50 Tons Daily in Long and Short Hauls on Skids with Electric and Hand Lift Trucks

IF A daily trucking load of approximately 100,000 lb. had to be moved by hand each time it was handled the total amount moved daily would be several times 50 tons, and would cost considerably more because hand-handling is one of the most expensive methods of moving materials.

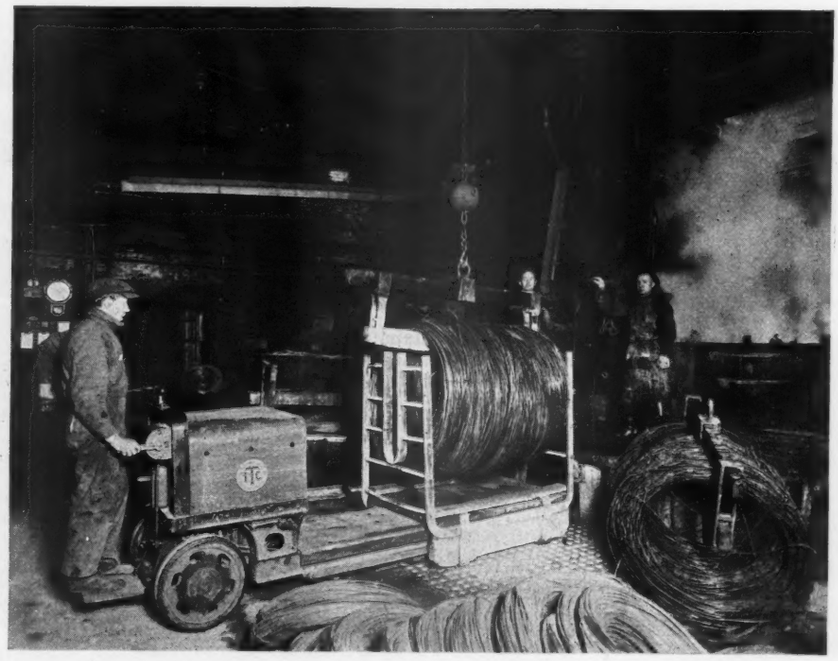
However, at the wire drawing plant of Geo. W. Prentiss & Company, Holyoke, Mass., even with this amount of tonnage, the hand-handling is reduced to a minimum by the use of two Cowan electric lift-platform trucks and six hand-lift trucks together with about 10 skids for the electric truck and about 50 box-type skids and racks for the hand trucks. From 1,000 to 5,000 lb. of rod or wire are handled at a time; the average load is approximately 2,000 lb.

The first step in the handling process, from freight car to outdoor storage, is made by horse-drawn trucks which transfer the coils of rod from 500 to 800 ft. When taken out of storage the coils are loaded onto rack skids and taken to the cleaning room by electric truck. Here they are removed by a pneumatic hoist, as shown in the accompanying illustration, and placed in the acid cleaning vats. When cleaned the wire is removed from the acid vats by the hoist and placed on an iron, bake-house truck. These are wheeled trucks and are pulled as a trailer by one of the electric trucks, which may also carry a loaded skid, to the rod frame department, 250 ft. away.

Here, after working, the wire rod is placed on skids and taken 400 ft. to the No. 15 frame where the wire is drawn and again goes onto a skid to be transferred to the annealing department. All of these have been hauls of several hundred feet and have been made economically by an electric truck. Also, after working in the other departments, the rod or wire is always piled directly upon the skid and so eliminates any extra handling or picking up which not only makes extra labor but also adds to the congestion. In the next two or three processes the wire is handled by overhead cranes and special dollies.

From this point of the process on to the spooling and shipping department, all of which are short hauls, the wire is handled from operation to operation in box skids on hand-lift trucks.

The electric lift truck, which was manufactured by the Cowan Truck Company, Holyoke, Mass., by its speed on long hauls and the greater ease in handling saves at least 8 men 9 hours a day over the former method of handling. At a rate of 45 cents per hour, this makes an actual saving of $32.40 per day or $9,720 in a 300-day year. It also must negotiate two grades; one of 14 per cent, 25 ft. long, and another 10 per cent grade, 15 ft. load. These are made under load.



Long hauls are made on an electric lift truck while hand-lift trucks are used for short hauls.

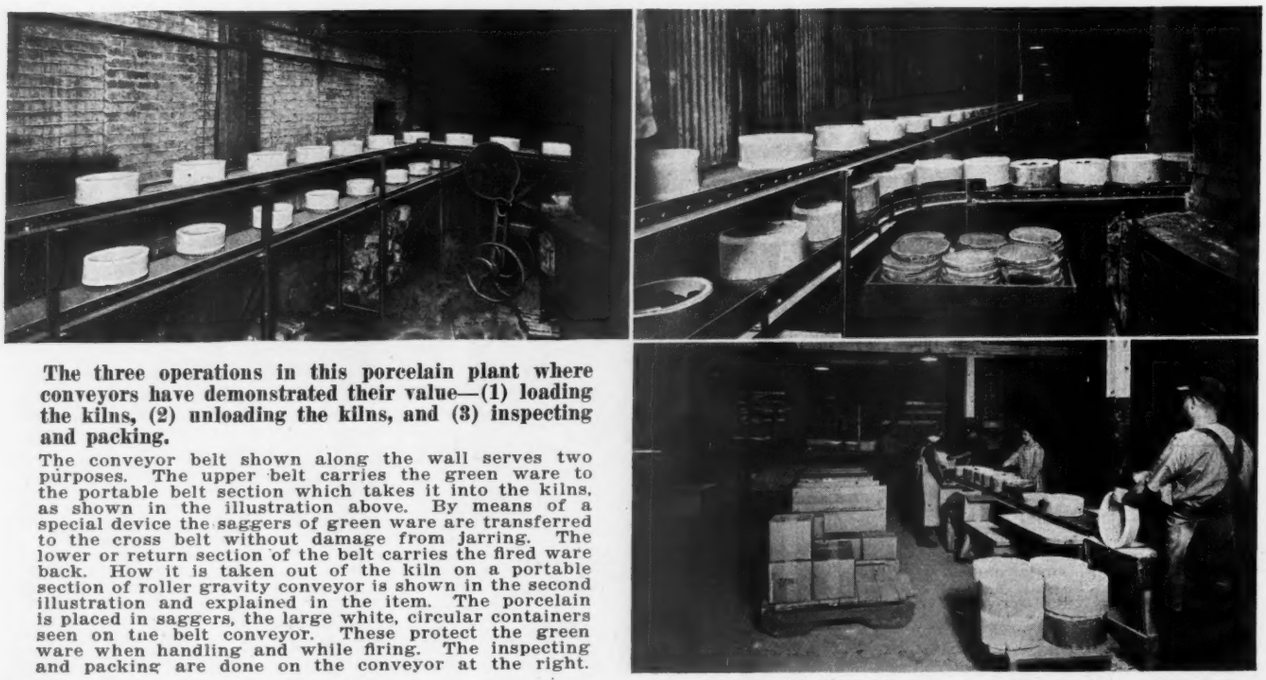
Wire and wire rod are bulky and inconvenient to handle. When placed in special racks on skids as shown here they can be easily moved mechanically. Altogether the trucks and skids save eight men a day at a total saving of $9,720 a year. This is considerably more than the cost of all the electric and hand trucks and skids.

Handling Porcelain at the Plant of the Square D Company by Conveyors

IN THE manufacture of porcelain and other fragile materials, the use of conveyors has often been discouraged because it has always been considered that too much jar and shock were necessarily connected with their use. However, when the Square D Company took over a porcelain factory at Peru, Ind., to make the porcelain parts connected with their safety switches and other electrical equipment, the entire method of handling materials was reorganized so that not only were they able to use conveyors, but also lift trucks. Perhaps the most radical departure from the common practice in porcelain work was in the method of loading and unloading the kilns. Under the old method of loading kilns the saggers, in which the unfired or green porcelain is placed for protection from heat and handling, were carried into the kiln by hand. It usually took a gang of from eight to ten men working both day and night, about twenty hours to fill a kiln. Now, however, two men in a kiln, one to pack the saggers in bungs and the other to assist him, will load a kiln in about nine hours. This makes it possible to fill a kiln in the daytime and fire it that night and so save several hours in the operation of a kiln.

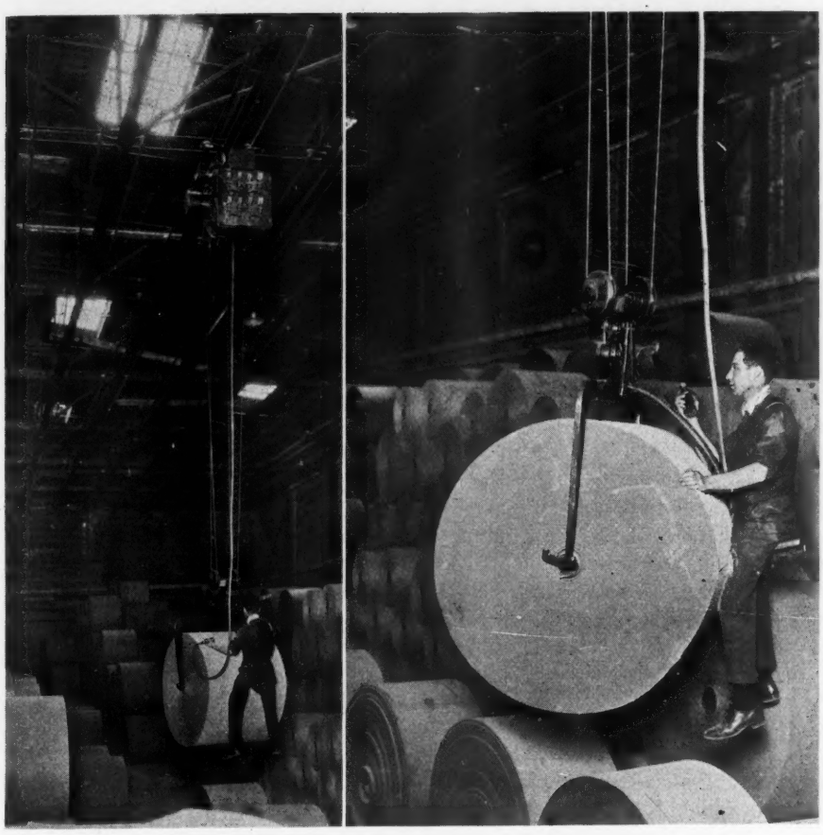
The handling of unfired porcelain by conveyors presented a serious problem. In the first place, the kilns are all in a row and a conveyor which would distribute the saggers to these kilns would have to have some arrangement for discharging them onto a cross conveyor which would enter the kiln. This was finally solved by installing a belt conveyor, as shown in the upper left illustration, which is 180 ft. long and 14 in. wide, and travels the full length in front of the kilns. The top of the belt is placed about 6 ft. above the floor or 3 ft. above the kiln door and is located about 8 ft. from the doors of the kiln. The transfer from the longitudinal belt to the cross belt conveyors feeding the kiln is made by a portable section of belt conveyor which is also shown in this illustration. In making the turn, it was necessary to prevent undue jarring and not permit the saggers to touch each other. This cross conveyor, which carries the saggers into the kiln, is so arranged that when it is clamped across the main conveyor belt it depresses it enough to provide clearance for the cross belt to fit in place at the same level as the conveyor belt. In this way saggers traveling on the main belt strike the section of cross belt which is traveling at a right angle and, as they are both traveling slowly, rotate slightly until they are transferred entirely onto the cross belt. Both of these conveyors travel at the rate of 24 ft. per min. To insure that the saggers are placed sufficiently far apart so that they do not have any chance to come in contact, marks are placed on the belt 4 ft. apart and the operator must see that only one sagger is placed between two marks. The saggers are discharged from the cross conveyor onto a bench in the kiln which will allow for temporary storage of several saggers in case they come in so fast as to crowd the men in the kiln. When a kiln is loaded, two men can transfer the cross conveyor to the next kiln in about half an hour, as it is mounted on two large wheels, which may be seen in the first illustration.

This longitudinal belt serves a double purpose in that it is also used for unloading the kilns by carrying the saggers filled with fired porcelain on the lower or return section of the belt. As the fired porcelain is not as fragile as was the green porcelain, the sagger is transferred from the kiln to the lower or return belt on a roller gravity conveyor as shown in the second illustration. This is provided with a turn section of small-diameter rollers at the lower end and deposits the sagger on the belt without any undue jarring. However, as the bottom of the saggers are rough or some of them may be broken, it is necessary for the unloaders to place each sagger of fired ware on a wooden pallet or



The three operations in this porcelain plant where conveyors have demonstrated their value—(1) loading the kilns, (2) unloading the kilns, and (3) inspecting and packing.

The conveyor belt shown along the wall serves two purposes. The upper belt carries the green ware to the portable belt section which takes it into the kilns, as shown in the illustration above. By means of a special device the saggers of green ware are transferred to the cross belt without damage from jarring. The lower or return section of the belt carries the fired ware back. How it is taken out of the kiln on a portable section of roller gravity conveyor is shown in the second illustration and explained in the item. The porcelain is placed in saggers, the large white, circular containers seen on the belt conveyor. These protect the green ware when handling and while firing. The inspecting and packing are done on the conveyor at the right.



With this hoist one man can do all the handling of the load as well as operate the hoist and travel.

With this quick-grappling device and the push-button control a helper is not needed to handle these heavy rolls of paper. Also the parallel I-beams properly spaced eliminate practically all aisle space and with the high piling possible get a very large storage capacity from the floor space. Direct current at 220 volts, supplied by a two-wire trolley, furnishes the power for the hoist and the travel motors.

board before placing on the roller gravity conveyor. This also keeps the saggers apart so that they do not strike on the roller section.

The third illustration shows how a section of roller gravity conveyor is used for inspecting and packing of the fired ware. The saggers on the pallet are diverted from the return belt conveyor onto this roller gravity section and pass along in front of girls who inspect and pack the fired ware as it passes by. The empty saggers and pallets go on to the end of the conveyor where the saggers are placed on a lift truck platform at one side and the pallets are piled onto another on the other side, to be taken back to the next kiln to be unloaded and used again. In the unloading, one man will unload a kiln in nine hours while another man handles the empty saggers and pallets. In addition, four inspectors inspect and pack. It formerly required five men working about twenty hours continuously to unload a kiln, as the saggers had to be carried out one at a time, were dumped and inspected later. Under the former method of handling, there was considerably more breakage.

The savings here are not only the decrease in the number of men required, but also it has been found that a great deal less breakage and spoiling of both green and fired ware has resulted than by the former hand method which up to that time had been considered the only practical means of handling porcelain. Also it enabled the company to get out a much larger production than had been thought possible. The total saving is not easily computed, but if only two men were replaced by this equipment the saving in their wages would more than balance the interest and depreciation charges. The Dow Company, Louisville, Ky., installed the conveying system.

How a One-Man Hoist Increases the Storage Capacity of a Paper Warehouse

AT THE Emeryville (Calif.) plant of the Paraffine Companies, Inc., a one-man hoist of special design is employed in handling large rolls of felt and paper to and from the storage warehouses, as illustrated in the two accompanying photographs. This hoist travels on a series of parallel I-beams which are bolted to the roof trusses and extend lengthwise of the warehouse, as shown in the photograph at the left, enabling the operator to deposit or pick up a roll at any point. Cross travel from one I-beam to another is made on a "cross-over" which operates on two tracks extending across the end of the warehouse. Both hoist and cross-over are controlled by the operator who rides on a seat with the load, as shown. The I-beams are spaced so that only the necessary room is left between the rows to enable the operator to grasp the roll. Instead of a hook and sling the crane is provided with a pair of heavy jaws which engage the core of the roll of paper as shown in the photograph at the right. These jaws are opened and closed by a hand lever controlled by the operator when he picks up or deposits a roll of paper. This type of clamp enables the operator to handle the heavy rolls without damaging, as would likely be the case if grasped in any other way than by the core.

The hoist is electrically operated on a 220-volt, direct-current circuit. The operator controls the entire movement of the hoist by four push buttons mounted on a base which is held in the right hand as shown in more detail in the illustration at the right. The buttons are marked, Raise and Lower, Forward and Reverse. The hoist is of 2-ton capacity with separate motors for hoist and trolley travel. It has a 24-ft. lift at a hoisting speed of 20 ft. per min. and can travel on the I-beam at a speed of 200 ft. per min. A special safety device prevents it running off the I-beam when transferring from one to another by means of the cross-over. The load is lifted by two cables which help to steady the operator and decrease swaying or swinging.

This installation, which was made by The Brown Hoisting Machinery Company, Cleveland, O., is particularly effective in conserving storage space by eliminating wide aisles which would be necessary with practically any other than an overhead method of handling and also in that the piles can be carried higher than is possible if the material is piled from the floor. CHAS. W. GEIGER.

San Francisco, Calif.

Ventilating Problems in Industrial Works

(*Continued from page* 376)

on the inside and decrease the liability of clogging. Round seams should also be riveted, although it is not necessary to space so closely. In addition, it is best to solder all seams, as open seams can easily cause a power loss of 10 per cent.

Fans are made either right or left handed and with the discharge pointed up or down, or horizontally at the top or bottom. Some manufacturers are making reversible or universal blowers or exhausters in the smaller sizes which can be made either right or left handed and the outlet can be adjusted to discharge at about each 30-deg. point in a complete circle. These are used for work which is likely to require numerous changes in the arrangement of the blower for other temporary installations. Frequently double blowers, two blowers attached to the ends of a belted shaft, are placed in the center of a building or department, with the suctions extending in opposite directions. This simplifies the operation, as it makes two shorter lengths of duct instead of one long section.

Ventilating by the Plenum Method

In the plenum system the air is forced into a building or room instead of pulled out, as in the vacuum method of ventilation. This puts the room under a pressure slightly greater than the atmosphere and so prevents infiltration of the outside air. The plenum system of ventilation distributes the air through ducts and is most generally used where the ventilation and heating systems are combined or where washed, cooled or humidified air is distributed around the plant. Frequently during warm weather air is forced through the heating system ducts and discharged into the room. The effect is to give not only a change of air but also to keep the air in circulation. With the plenum system air can be distributed to a specified place in the quantity and at the temperature desired; it is absolutely under control. Some of the methods of distribution are shown in the accompanying illustrations. Much depends upon the construction of the building, as is well illustrated here.

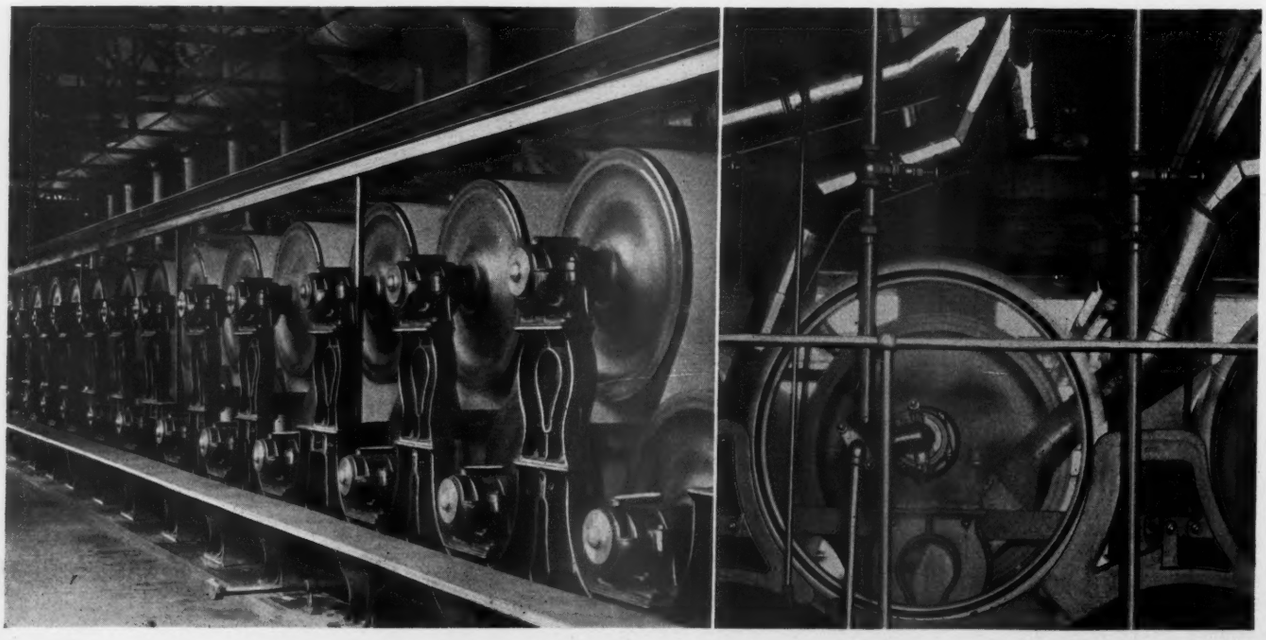
Frequently an exhaust system is used in connection with a plenum system, either to speed up the circulation or to carry the air back to the fans and recirculate it. If the air gathers much dust, moisture or heat it must be treated before using again.

Another factor which is of extreme importance in ventilation is the humidity. Air always contains a certain amount of moisture, but the amount which it can contain—saturation point—depends upon the temperature. For example, at 57 deg. F. one cu. ft. of air will absorb 6 grains of water; at 86 deg. F. the same volume of air will hold 12 grains or twice as much water. Approximately each 27 deg. F. increase in temperature doubles the amount of water vapor any given weight of air can carry. When air becomes saturated with water vapor and is cooled to a lower temperature it becomes supersaturated and the water vapor condenses out as moisture.

Air at any temperature, however, does not always contain the same amount of water vapor. Industrial conditions give a wide range of dryness and moisture in the air. This is measured by the relation of the amount of moisture actually contained in the air to the amount which could be contained if the air at that temperature was saturated. This ratio is called the "relative humidity," and has an important bearing in many industrial ventilation problems. A high relative humidity causes discomfort, lack of energy, and may effect the health. In explanation, the body temperature is maintained at 98½ deg. F. by the cooling of the blood through the evaporation of the "sweat" due to heat or labor.

If the relative humidity is high—that is if it is saturated with water vapor—it cannot evaporate the perspiration. It is like using a wet sponge to wipe a surface dry. The

Removing water vapor and heat in the process of making paper.
Two pounds of water per pound of paper is evaporated at the paper machines. This must be removed before it can condense on the ceiling. The smaller illustration shows how the exhaust ducts are carried low enough to get most of the vapor at the rolls. Openings higher in the room collect whatever escapes.



Two types of air outlets and a hood for collecting steam and fumes from cooking.

One type of air outlet is shown in the insert. This discharges the air above a man's head and in each direction. How vanes in the duct outlet direct the air is shown just above the insert. These are primarily heating systems but the same ducts are often used in the summer time to distribute fresh air and keep the air in the rooms in circulation. Frequently the air is washed and cooled before circulating. The left half of the picture shows how hoods are connected up with a separate exhaust system to remove the fumes and steam from the kettles. Hoods of this type are often made telescopic so that they may be lowered while cooking and raised while the kettles are being emptied.

result is that the evaporation ceases and the heat of the body rises. One experiment found that in almost saturated air at 94 deg. F. the temperature of the body rose 4 deg. F. in two hours, and with hard work rose 4 deg. F. in one hour. However, the body temperature was not affected by a temperature of over 130 deg. F. with a low relative humidity of almost 18 per cent, because the comparatively dry air evaporated the perspiration very rapidly and kept the body temperature at normal.

The solution of the problem of lowering the relative humidity in any department of an industrial concern consists in forcing in air of low humidity which will make a mixture of considerably lower relative humidity than the air already in the room. It is generally necessary to remove this mixture as soon as possible by a combination of a hood and an exhaust system. This is one of the situations where plenum and vacuum ventilating systems are used in combination.

The manufacture of paper furnishes one example of an industrial process creating a high humidity. In the manufacture of paper approximately two pounds of water are evaporated for each pound of paper produced. The air which absorbs this moisture is almost saturated and must be removed before it can condense upon and rust out the ceiling and spoil the paper by dropping from the rusted ceiling upon the work. Since air as the temperature is increased shows a lower relative humidity and can absorb more water vapor, the air supplied by the plenum system is usually heated. For example, air at 70 deg. F. with a relative humidity of 60 per cent can absorb about twice as much water vapor, before becoming saturated, by heating to 85 deg. F. Additional increases in temperature will increase the capacity of absorption. Dye works, open cooking vats, the manufacture of hats and other objects formed from felt, and several other industrial processes all offer the problem of removal of excess water vapor from the air.

Creating "Artificial Weather" for Industrial Processes

In some industries the humidity of the air, which depends upon the weather, is sometimes too low and at other times too high for the best operation. For example, in high-class color printing and off-set color work the paper stretches on wet days and shrinks in dry weather. It is a small amount, to be sure, but it is enough to shift the "register" so that the colors do not fit in on each other as they should. Sometimes in rainy weather printing had to stop because the paper would stretch with each handling. Now, by keeping the paper stock and the printing process in a closed room and supplying air at a definite temperature and humidity, some plants are able to disregard the outside weather entirely. Spinning cotton into thread is another process formerly dependent upon the weather which has been made independent by air conditioning. In these processes and several others, air of lower and at other times of higher relative humidity than the outside air must be put into a room.

The amount of power used and the speed of the fan or blower are the principal features in determining the method of drive. Formerly almost all blowers and exhausters were belted, but the rapid increase in the use of motors has resulted in a large proportion of those units which require a considerable amount of power being direct connected to motors. The same development has been the primary cause in improving the design and efficiency of centrifugal fans. Formerly there were a limited number of standard sizes, one of which would be selected and might or might not meet the conditions. Often a small blower was driven at excessive speed to do work which a larger one would have accomplished with much less power. Nowadays blowers are designed to order for certain definite air quantities and pressure, and to suit the available motor speeds. These blowers, besides being built to fit the job, are more efficient than the stock sizes.

Individual motor drive for ventilating fans is usually desirable. Fans should be belt driven if their slow speed would make the motor unduly expensive and there is no advantage in economizing floor space. In some cases the operating conditions given change after a time, and it is easier with a belted fan to change the pulleys and (*Continued on page* 410)

Operation of Fire Alarm Systems

(*Continued from page* 383)

The new control panel consisted of one single-pole 100-amp. 250-volt magnetic contactor switch, the operating coil being supplied with 250 volts through the contacts of a closed-circuit relay. The operating coil of the latter is in series with the alarm-box circuit and required 16 primary cells, eight volts potential, to furnish the 0.2 amperes necessary to hold the relay closed against a spring.

Gong Circuit Divided Into Sections Reduces Wiring

At the main switch the gong circuit was divided into three lines serving various sections of the plant, in order to reduce the amount of wire necessary to reach all gongs. Inasmuch as one side of the circuit was permanently grounded, it was necessary to run only one wire for each gong circuit required, the path to ground being completed at each gong. With non-grounded systems it becomes necessary, of course, to use two wires in each circuit. One vibrating or continuous-ringing type of bell was installed in the power house, where the control panel is located, in order to indicate when the box circuit opened and did not close again, which might be due to a break in the line, a defective switch in an alarm box or to exhausted primary batteries. In the event of such trouble the switch controlling the gong circuit can be pulled at the power house, in order to prevent the operating coils of the gongs being burned out. As soon as the electrician finds the trouble and corrects it the switch can be restored.

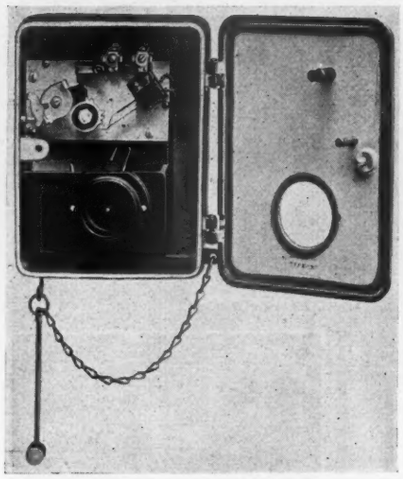


Fig. 3—Call box connected in series with operating coil of closed circuit relay. This box is made by the Autocall Company, Shelby, Ohio.

A set of switches was also installed for testing out the box circuit by means of 250-volt lamps. The box circuit may be operated at 250 volts while testing the primary cells, or continuously, if desired, and by another arrangement of switches may be tested for grounds, as is indicated in the diagrams.

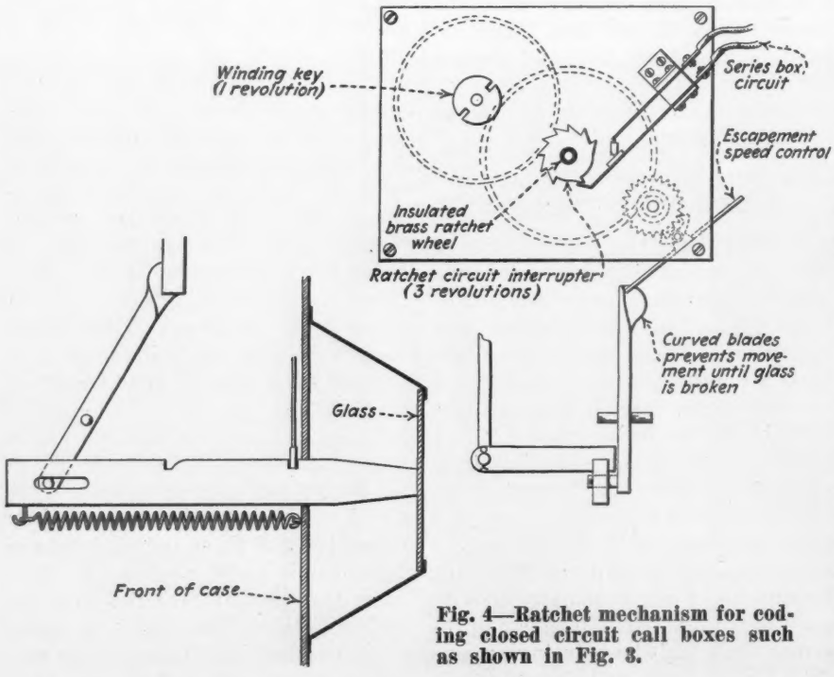


Fig. 4—Ratchet mechanism for coding closed circuit call boxes such as shown in Fig. 3.

Cutting Out Coils in D. C. Windings

(*Continued from page* 389)

proportion to the number of turns that are removed. By cutting out coils in a motor the speed and probably the horsepower will be reduced.

Repairing Mica and V-Rings Without Removing Commutator

Sometimes a coil will be short-circuited through breakdown of the mica between commutator bars or in the insulating V-ring. In this case repairs may often be made without taking the commutator apart. For this you should have some plaster of paris, a good grade of orange shellac (clean) already mixed in air-tight cans and some strips of pure mica. If the mica between bars becomes carbonized not over ¼ in. deep before the short circuit is cleared the hole may be filled. To do this run some shellac into the hole, then make a mixture of plaster of paris with the shellac to form a thick paste. Pack this paste into the hole, smoothing off the top surface flush with the commutator and allow the paste to dry.

To illustrate the use of pure mica the following incident will indicate the possibilities of getting a machine back in service without rewinding or removing the commutator. An armature out of an elevator motor was brought to the shop to be repaired as quickly as possible. The customer intended to install new equipment in the future and therefore did not want to go to any more expense than was absolutely necessary.

This armature had one coil burnt out, a short circuit between two bars on one side of the commutator and a short circuit between three bars on the side directly opposite. The middle bar had been grounded at the front V-ring. Two of the coils were cut out and two of the short-circuited bars were jumped. This left one grounded bar and the other short-circuited bar which had to be repaired. To clear the ground the V-ring was scraped out from under the bar ¼ in. back. To clear the short circuit between bars the mica on each side of the bar had to be dug out all the way down to the V-ring and extending back about 1 in. When the coil tested clear on 220 volts alternating current, shellac was poured into the scraped parts.

Then pure mica was cut into strips, 1 in. by ½ in. in size and folded over until it was thick enough to make a tight fit in the crack. It was pushed into the crack and then rammed home with a thin drift (made of a hacksaw blade) and hammer. Then more shellac was poured in and the operation was repeated until the cracks were filled. The space in the V-ring beyond the commutator was filled in with paste and a cord band, three layers high was put on and well shellacked between layers. These repairs took only 4½ hours but the armature was still in good shape eight months later when the new equipment was installed.

An Analysis of Steel Mill Motor Failures

(*Continued from page* 381)

to the frame often have the base loosen. Since the electric shop does not have the facilities for riveting the base, the manufacturer is called upon to take care of such cases. It has been found best to bolt the frame and base together. On certain types of induction motor frames the bosses on the end bells break off and let the bells down low enough to allow the rotors to rub on the stators. When repairing, larger bosses are put in.

Frame Repairs on Direct-Current Motors

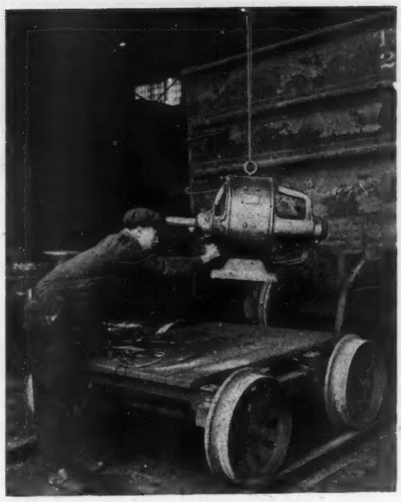
On d. c. motors the bulk of the required frame repairs is on the field coils. Interpole field coils loosen and vibrate on the pole pieces and then ground; also, they burn out, due to overloads. Series coils burn out from overloads and from heating due to loosening of the connections at the coil terminals. This last fault is particularly prominent in the enclosed mill-type motor. Shunt field coils are usually damaged by causes external to themselves, such as "fanning" of the armature, fires in the motor, overheating or burning due to overloads or shorts in the series field coils or adjacent interpole coils.

It has not been found practical to wind field coils in the shop. The demand is small and a few spares are kept in stock. Quite often the coils are not so badly damaged that they cannot be reinsulated and used.

On the enclosed-type motors the porcelain, brush-holder insulators often break or crack, causing a "ground" which soon burns the studs. The insulators are replaced with new ones and new studs are made by the machinist. The brush holder springs sometimes break or lose their tension, but new springs can be easily inserted in the old holders.

Before a motor is disassembled the air gap is checked and the bearings are inspected. It is usually cheaper to make new bearings in the shop than to buy them from the manufacturer. For the small motors brass bushings are turned up from brass castings or from extra heavy seamless brass tubing. For the medium sized induction motors and the adjustable and constant speed d. c. motors, seamless steel tubing is turned to size and babbitted. For the larger motors and for the enclosed-type mill motors, a few spare bearings are kept on hand to replace worn ones. The worn ones are rebabbitted and thus new spares are obtained.

Oil rings for all armature and rotor bearings can be made from seamless brass tubing at very little expense.



Loading small motor on car for transfer to repair shop.
This motor was removed from a cut-off saw in the pipe mill and carried to the tracks at the end of the building by a crane. The remainder of the trip to the repair shop requires in this case a run of about 1,000 ft. on a car propelled by a gasoline engine.

Assembling the Bearings in Motors

When assembling the bearings in the motor, care is taken to see that the dust rings and end caps are in good condition; also, that the oil plugs and the oil hole covers are all right. A tightly enclosed bearing will avoid a lot of trouble from bearing cutting.

Before the motor is assembled, the armature, the inside of the frame and the field coils are painted with air-drying insulating varnish. The motor is then assembled and tested. A dielectric test is given to all windings upon their completion. The motor is given a no-load run, is rapidly reversed a few times while the commutator is being observed, and in the case of some of the adjustable speed motors a load test is given. The motor is then ready to be held as a spare until the need for it arises on some other trouble job or breakdown.

Removing small open-type motor from foundation by use of crane.
This motor, which is used to drive a cut-off saw, is about to be lifted off its base by the traveling crane for transfer to the repair shop. All small motors are taken to the shop for vital repairs, a spare motor being substituted for the defective one during the repair period.

Trade Literature
you should know about

Federal Electric Company, 8700 South State Street, Chicago, Ill.—A small folder, vest-pocket size on heavy paper, gives the fuse ratings for motor circuits supplying induction and direct-current motors.

Electric Furnace Construction Company, 908 Chestnut Street, Philadelphia, Pa.—A recent bulletin describes the "Electro" steam boiler developed by F. T. Kaelin, which generates steam by the passage of high voltage alternating current between specially designed electrodes immersed in water. One 2,000 kw. installation is claimed to be able to raise 6,000 lbs. of steam per hour to 130 lbs. pressure. Standard 3-phase units are made to operate from 550 to 12,000 volts and generate from 35 to 2,400 boiler horsepower.

Killark Electric Manufacturing Company, 3940 Easton Avenue, St. Louis, Mo.—Recent literature describes the Type FB entrance fitting for 2½ and 3-in. conduit. This consists of three pieces; a cover, a hub, and a plate which will hold 2, 3 or 4 porcelain bushings. By changing the relative positions of the hub and cover this fitting may be used on either a horizontal or vertical pipe.

Mueller Electric Company, 2135 Fairmont Road, Cleveland, Ohio.—A group of small folders describes the Universal test and battery clips made by this company. These come in 10, 20, 50, 100, and 200-amp. ratings.

Harvey Hubbell, Inc.—A series of leaflet circulars lists and describes the T-taps, T-caps, plugs and other attachments for lighting and light power circuits.

The Stuebing Truck Company, Cleveland Ohio—A group of bulletins put out by this company describes the operation of Stuebing lift trucks in various types of work such as handling sacked material, sheet metal, paper, package and case goods, and machine shop products.

The Cincinnati Electrical Tool Company, 1501 Freeman Avenue, Cincinnati, Ohio—A small circular describes the several "Cincinnati" portable electric drills and grinders.

Electric Furnace Construction Company, 908 Chestnut Street, Philadelphia, Pa.—A recent bulletin describes this company's line of "Graves-Etchells" electric furnaces for melting, refining and superheating iron, steel or alloys. These are made for both the basic and the acid processes.

A. H. Peterson Manufacturing Company, Milwaukee, Wis.—Recent literature describes the line of auxiliary equipment such as grinders, brushes, buffers, rotary taper files, and a commutator saw-wheel on a flexible shaft which are used with the "Hole Shooter," a portable electric drill, on a portable, radial drill press stand.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—Leaflet No. 3428 describes rolling contacts for direct current, magnetic contactor controllers, drum contactor controllers, motor starting switches and auto starters.

Roller-Smith Company, 233 Broadway, New York City—Bulletin No. 560 gives prices and other information on the types E and F, Roller-Smith enclosed circuit breakers.

The Formica Insulation Company, 4614 Spring Grove Avenue, Cincinnati, Ohio—A group of small booklets describes Formica insulating material and how it may be machined and formed into any required shape. This is made of specially prepared paper or fabric thoroughly impregnated with Redmanol resins and transformed by means of heat into a hard, strong, infusible and insoluble laminated material. It is made in sheets, rods or tubes. One of the important uses is for noiseless gears and pinions which do not absorb oil and so can run immersed in oil. Other uses as insulators are described in other folders. This material is also used for pump valves.

Victor Products Corporation, 560 West Van Buren Street, Chicago, Ill.—A small folder illustrates a special soft metal, double-faced hammer in which the face is removable and can be replaced with a new one. Special faces are supplied in babbitt, copper, brass, fibre and rawhide. One particular feature is that the two faces can be fitted with different materials, as for example rawhide in one face and babbitt or harder metal in the other, or a soft and a harder metal in the two faces. This gives a double-purpose hammer.

Joseph Weidenhoff, 4352-8 Roosevelt Road, Chicago, Ill.—Bulletin No. 951 gives the method of testing starting motor and generator armatures with the "Weidenhoff Duplex Growler."

Link-Belt Company, Chicago, Ill.—Book No. 567 gives details of construction of the several types of Link-Belt locomotive cranes. These are made for steam or electric service and are the crawler type or for operation on rails.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—Leaflet No. 1,824, "Arc Welding in Electric Railway Shops," just issued describes the many advantages of arc welding and gives figures showing the savings possible by reclaiming worn-out parts.

Ventilating Problems in Industrial Works

(*Continued from page* 407)

thus secure an increase in speed so as to provide additional capacity.

There is no more occasion for trouble with motors driving ventilating fans than with any other class of work, and, as a rule, there will be less trouble, due to the fact that the load is constant and within the capacity of the motor. Frequently fractional horsepower motors are neglected and cause trouble from lack of cleaning and lubrication. This is particularly likely to be true where no one is directly responsible for their maintenance. Blower motors, as a rule, operate under favorable conditions, and if given the ordinary attention, will give excellent service. The blowers themselves also require very little attention. In the case of high-speed fans, particularly those which operate in dusty places, the rotors should be kept clean to prevent getting out of balance. After the dampers and outlets are once set, the only attention that the rest of the system requires is occasional inspection to see that it has not been disturbed so as to unbalance the ventilating system by closing or opening the outlets.

A blower motor requires no special characteristics, as the starting torque is light. In most cases constant speed motors are desirable, but for ventilation and certain other service it is necessary to have considerable speed variation. Since the horsepower required to drive centrifugal fans varies as the cube of the speed, this variation when obtained with a direct-current motor is not too uneconomical if the greater part of the speed control is by armature resistance, using field control for the upper part of the range.

(Acknowledgment is made to the following concerns for assistance in supplying information and illustrations: American Blower Co., Detroit, Mich.; Arex Co., Chicago, Ill.; Autovent Fan & Blower Co., Chicago, Ill.; Buffalo Forge Co., Buffalo, N. Y.; Carrier Engineering Co., Chicago, Ill.; Globe Ventilator Co., Troy, N. Y.; Ilg Electric Ventilating Co., Chicago, Ill.; Kimble Electric Co., Chicago, Ill.; and, B. F. Sturtevant Co., Hyde Park, Boston, Mass.—Editor.)